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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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February 14, 1968

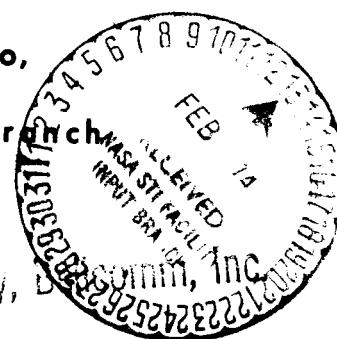
# PREFLIGHT TRACKING DATA FOR THE LAUNCH PHASE OF A LUNAR MISSION

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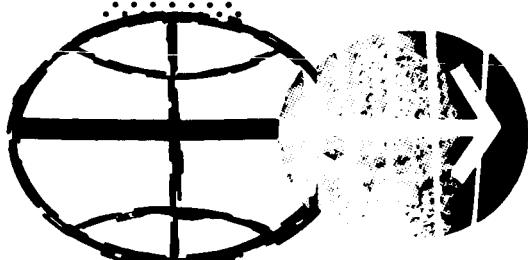
By Edward M. Jongo,

Lunar Mission Analysis Branch

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MISSION PLANNING AND ANALYSIS DIVISION



MANNED SPACECRAFT CENTER  
HOUSTON, TEXAS

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FOR THE LUNAR PHASE OF A LUNAR MISSION  
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PROJECT APOLLO

PREFLIGHT TRACKING DATA FOR THE  
LAUNCH PHASE OF A LUNAR MISSION

By Edward M. Jiongo  
Lunar Mission Analysis Branch

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February 14, 1968

MISSION PLANNING AND ANALYSIS DIVISION  
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION  
MANNED SPACECRAFT CENTER  
HOUSTON, TEXAS

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PREFLIGHT TRACKING DATA FOR THE LAUNCH PHASE  
OF A LUNAR MISSION

By Edward M. Jiongo

SUMMARY AND INTRODUCTION

This note provides radar tracking information for the Saturn V launch trajectory of a lunar mission for any launch opportunity during a monthly launch window. The data contained in this report are similar in content and arrangement to the data contained in reference 1. This note contains tracking information from lift-off to 15 minutes ground elapsed time (g.e.t.), or approximately 3 minutes after insertion, whereas reference 1 contains information from earth orbit insertion to 4.5 hours g.e.t. This document also contains keyhole information for the Bermuda and Antigua unified S-band system (USBS) stations.

All of the data in this report were generated using the Apollo Reference Mission Program (ARMP). The station characteristics are in reference 2. Launch profiles for azimuths from  $72^\circ$  to  $108^\circ$  were computed in steps of  $1^\circ$ .

The target conditions at earth orbit insertion were furnished by MSFC. Target conditions in the future will deviate somewhat from the presently available data, but these deviations are not expected to change the launch profiles significantly. At most, future changes and updates will probably only shift the tracking data curves by a small constant bias.

Discussion of Figures

Figure 1 shows the complete tracking histories for each launch azimuth from lift-off to 900 seconds g.e.t. From these plots it can be determined which station will be tracking, duration of pass, and station tracking overlap.

Individual station histories are shown in figures 2 through 12. For example, figure 4 provides a detailed history for the Bermuda USBS station. Figure 4(a) shows g.e.t. for  $5^\circ$  elevation at acquisition and loss versus launch azimuth. Figure 4(b) shows duration of pass above  $5^\circ$  elevation versus launch azimuth. Figure 4(c) shows azimuth of acquisition at  $5^\circ$  elevation versus launch azimuth.

Figure 13 shows the angle between the station-centered spacecraft position vector (keyhole vector) and the north-south axis of the station versus g.e.t. for each launch azimuth from  $72^\circ$  through  $108^\circ$  in increments of  $1^\circ$ . This figure shows the time history of the keyhole vector and may be used to determine the time spent in the keyhole, and possible keyhole overlap for any value of the keyhole half-angle up to  $20^\circ$ . Figure 13 shows the change in the keyhole half-angle with respect to g.e.t. for the Bermuda and Antigua USBS stations. (Only the USBS stations have the keyhole constraint.) Bermuda and Antigua are the only two USBS stations that do show a possible keyhole problem during the launch phase.

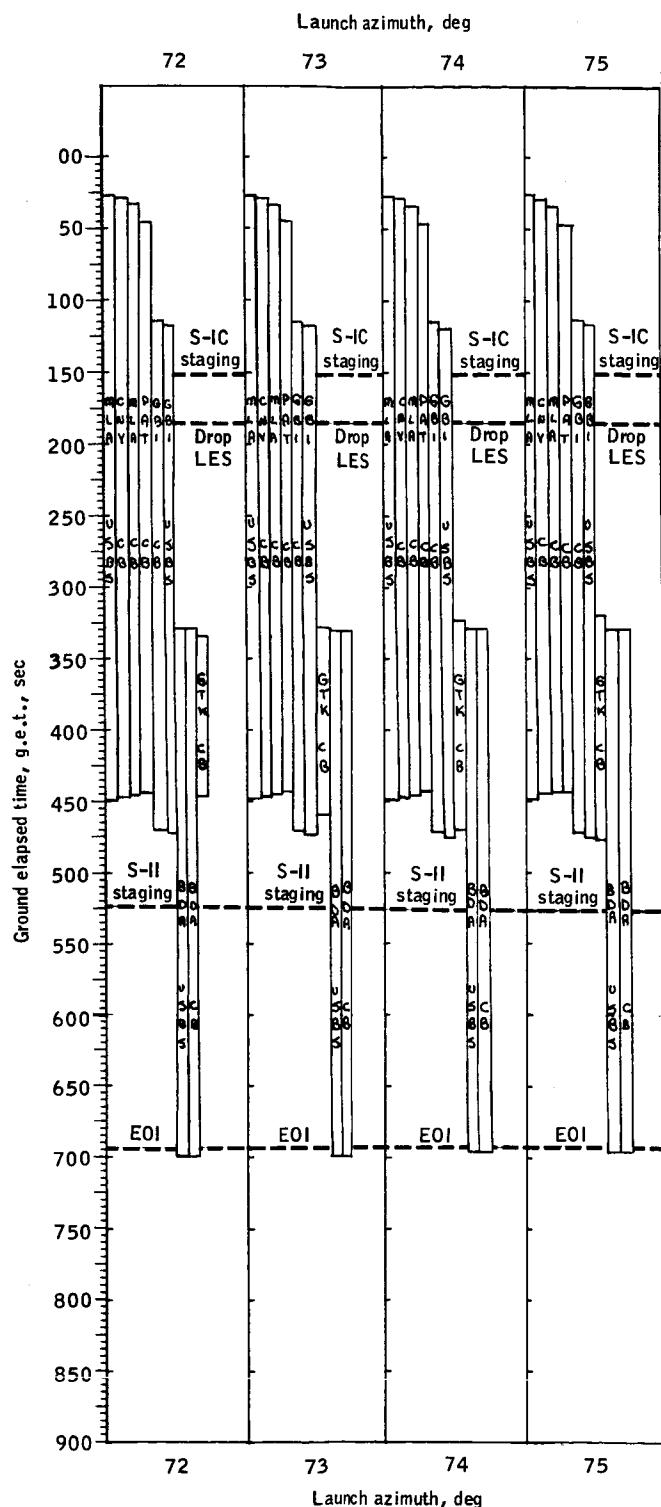
It will be noted that the curves for both stations are essentially parabolic. In those plots such as figure 13(s) one branch of the parabolic curve is truncated because of the minimum elevation constraint.

Keyhole information for launch profiles of  $72^\circ$  to  $87^\circ$  launch azimuth are not shown in figure 13 as no keyhole half-angle less than  $20^\circ$  is encountered in this azimuth region.

Figure 14 shows the keyhole effect for Antigua and Bermuda USBS stations using keyhole half-angle cones of  $14^\circ$  and  $6.6^\circ$ , respectively. It is a typical example of the information that can be obtained from figure 13 and represents the current constraint values for these two stations. From this figure it can be seen that no keyhole overlap is encountered during the launch phase.

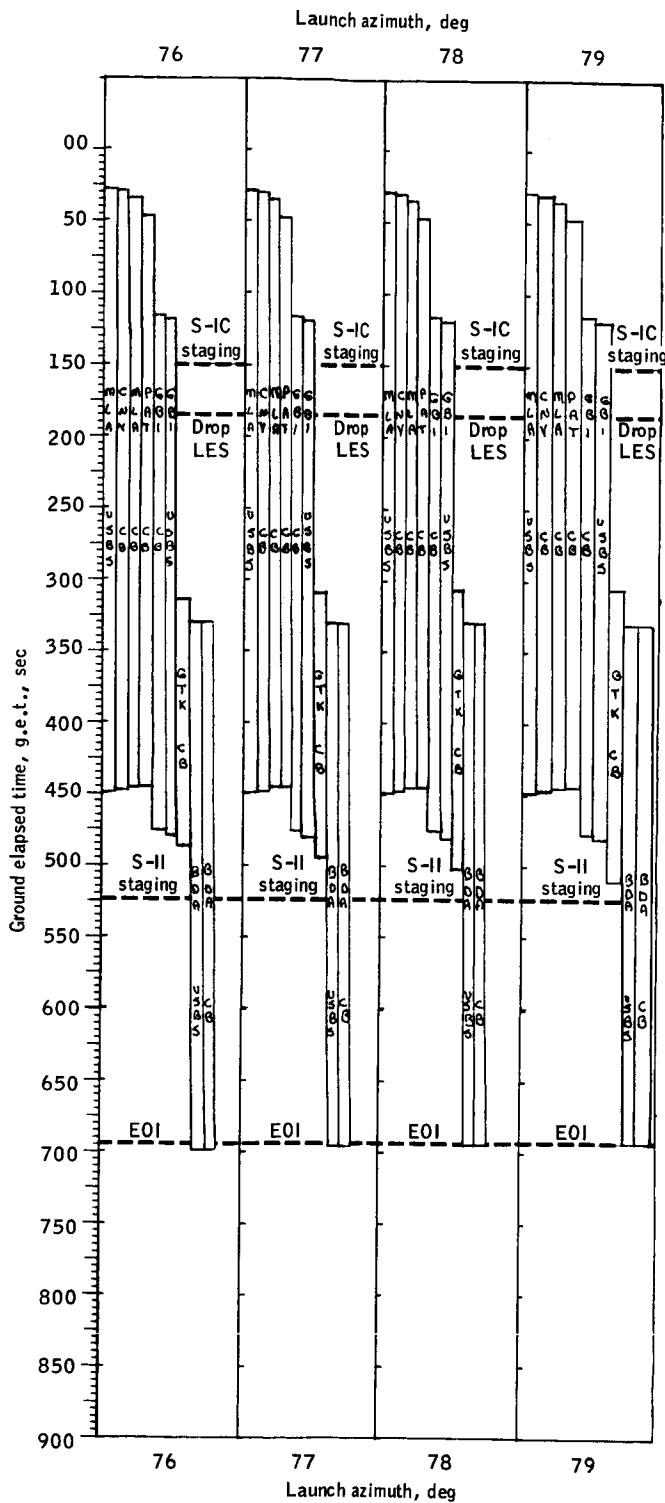
#### CONCLUSIONS

Although the present communications and tracking system was set up to provide adequate coverage for any launch azimuth between  $72^\circ$  and  $108^\circ$ , there are naturally certain launch azimuths which provide more coverage than others. Antigua can provide some postinsertion tracking for launch azimuths greater than about  $96^\circ$ . For the remaining available launch azimuths a tracking ship in the Atlantic Ocean is needed to provide most of the required 3 minutes of postinsertion tracking.



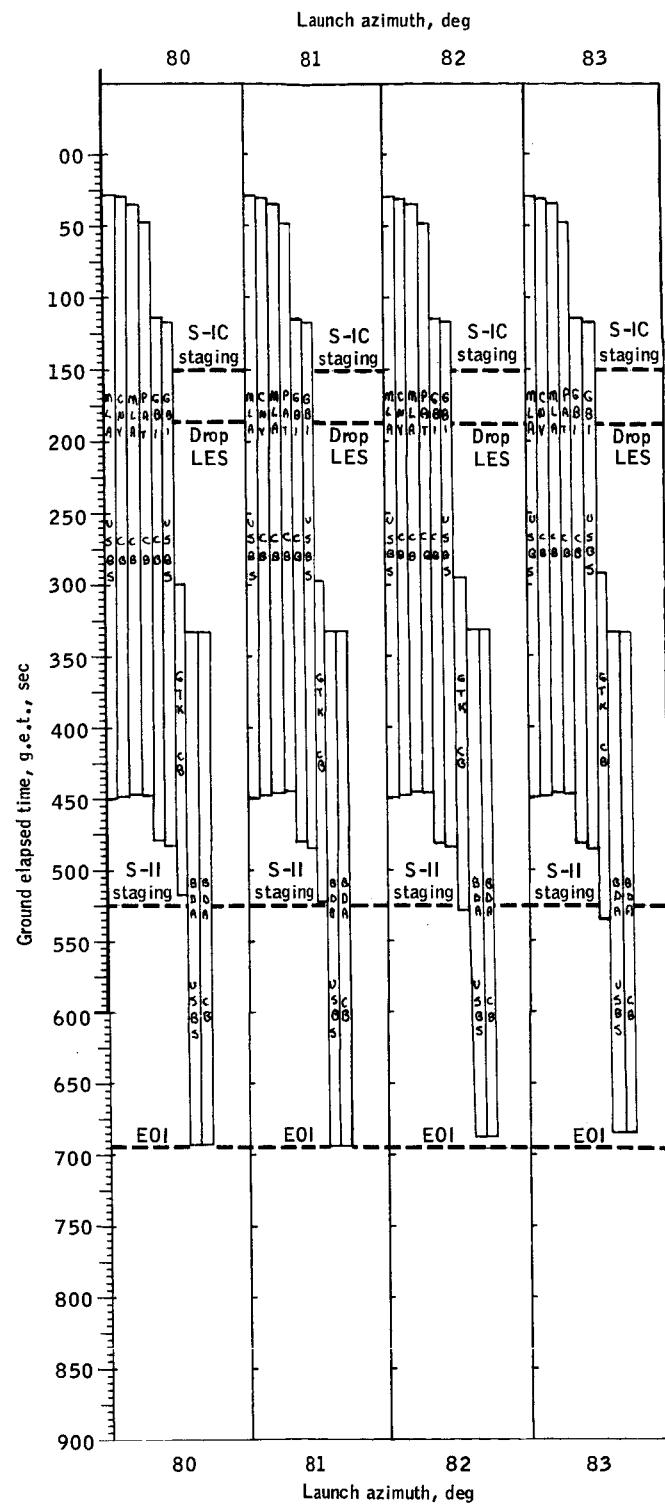
(a) Launch azimuths from 72 to 75 degrees.

Figure 1.- Tracking history for various launch azimuths from lift-off to 900 seconds ground elapsed time.



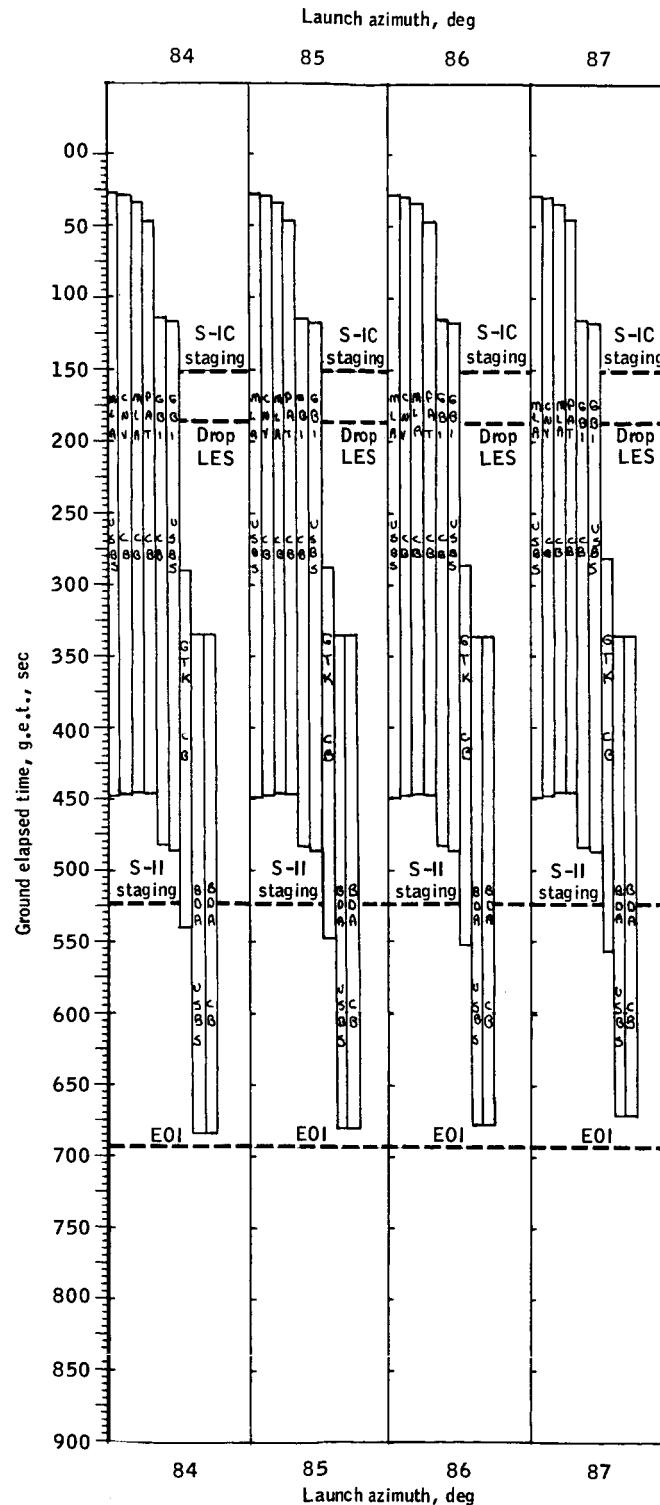
(b) Launch azimuths from 76 to 79 degrees.

Figure 1.- Continued.



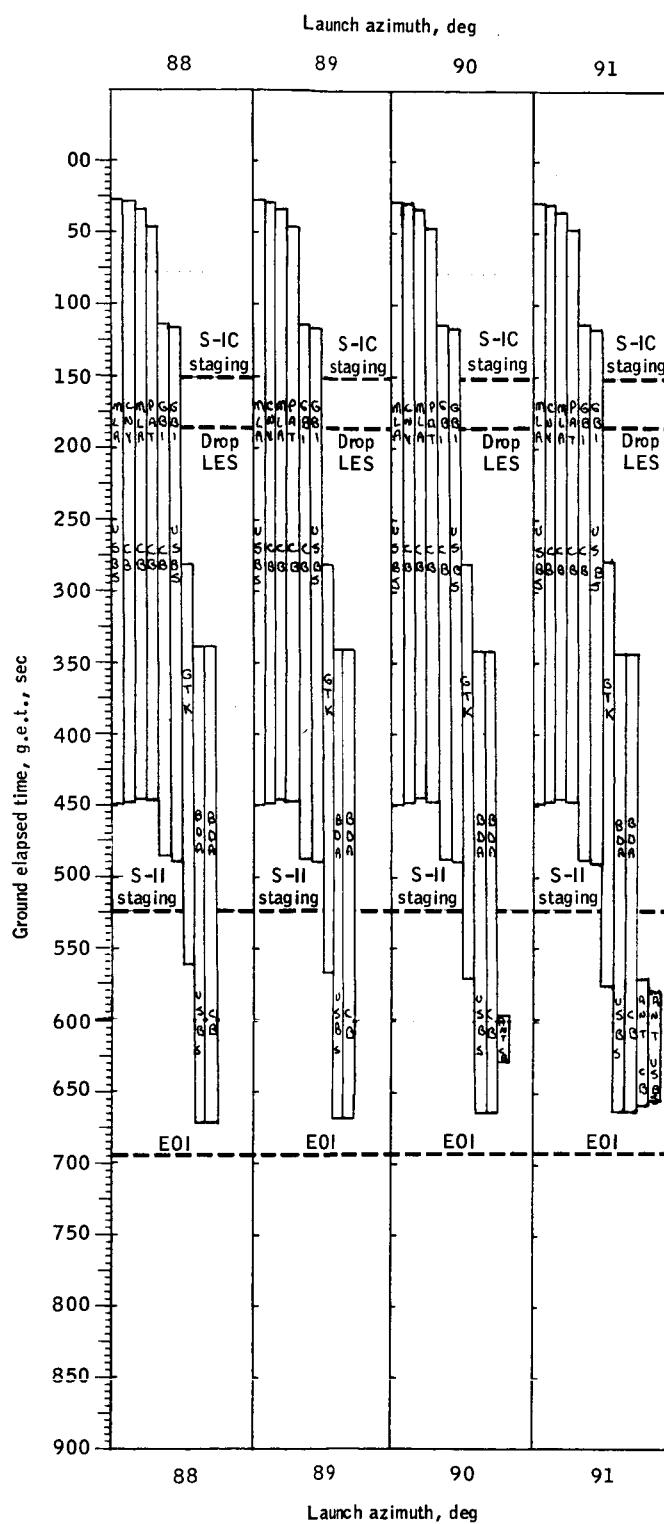
(c) Launch azimuths from 80 to 83 degrees.

Figure 1. - Continued.



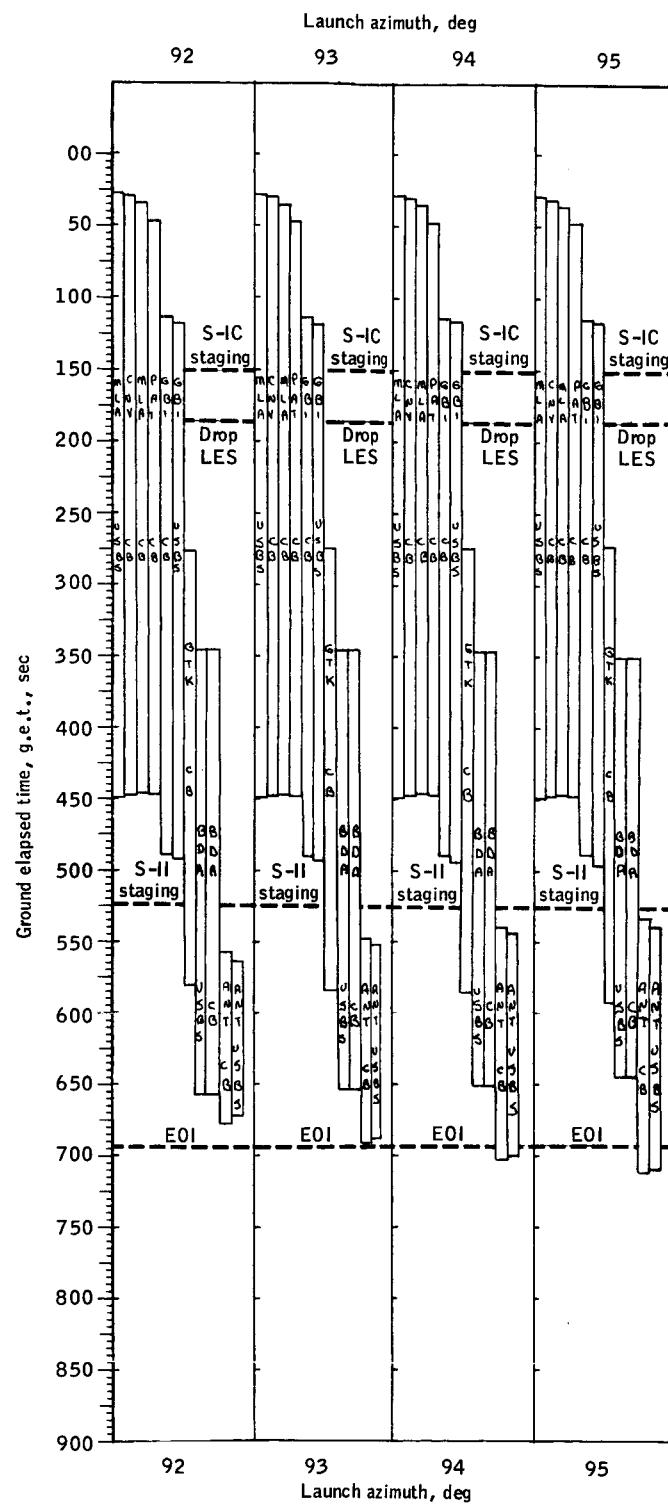
(d) Launch azimuths from 84 to 87 degrees.

Figure 1.-Continued.



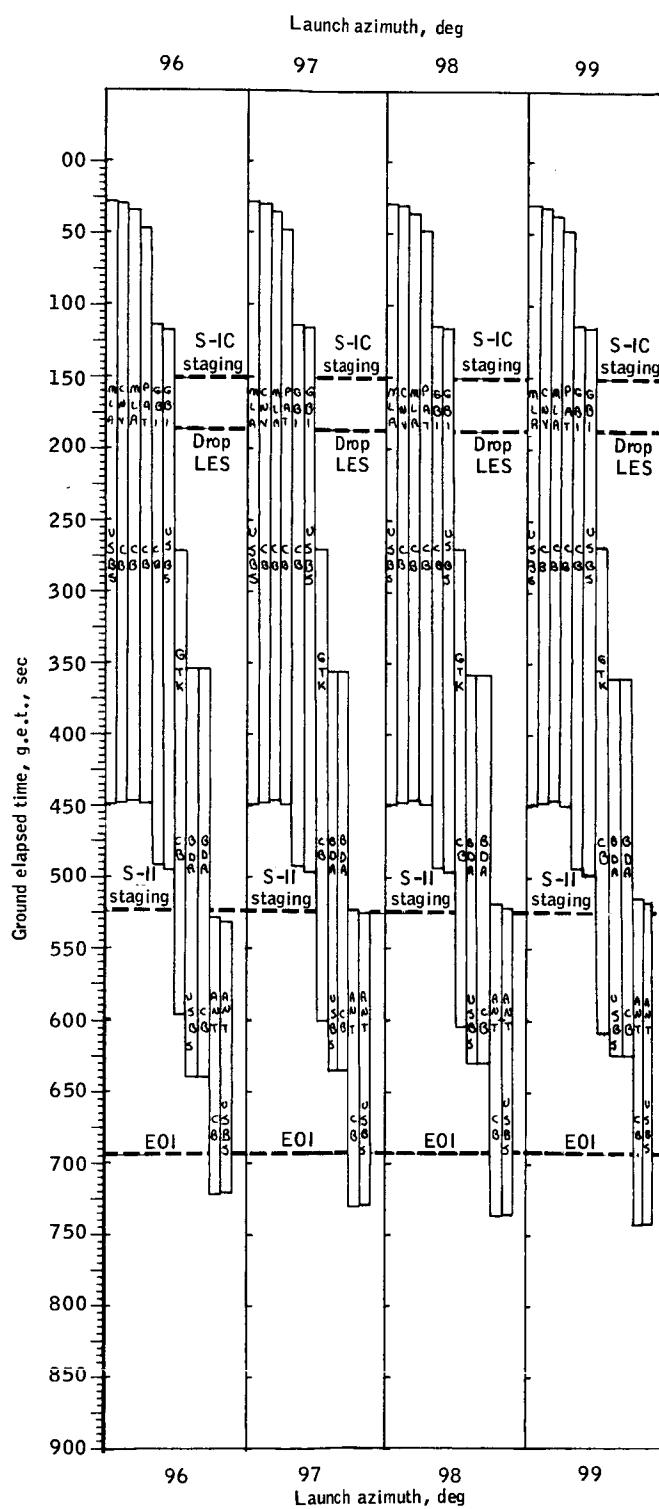
(e) Launch azimuths from 88 to 91 degrees.

Figure 1.- Continued.



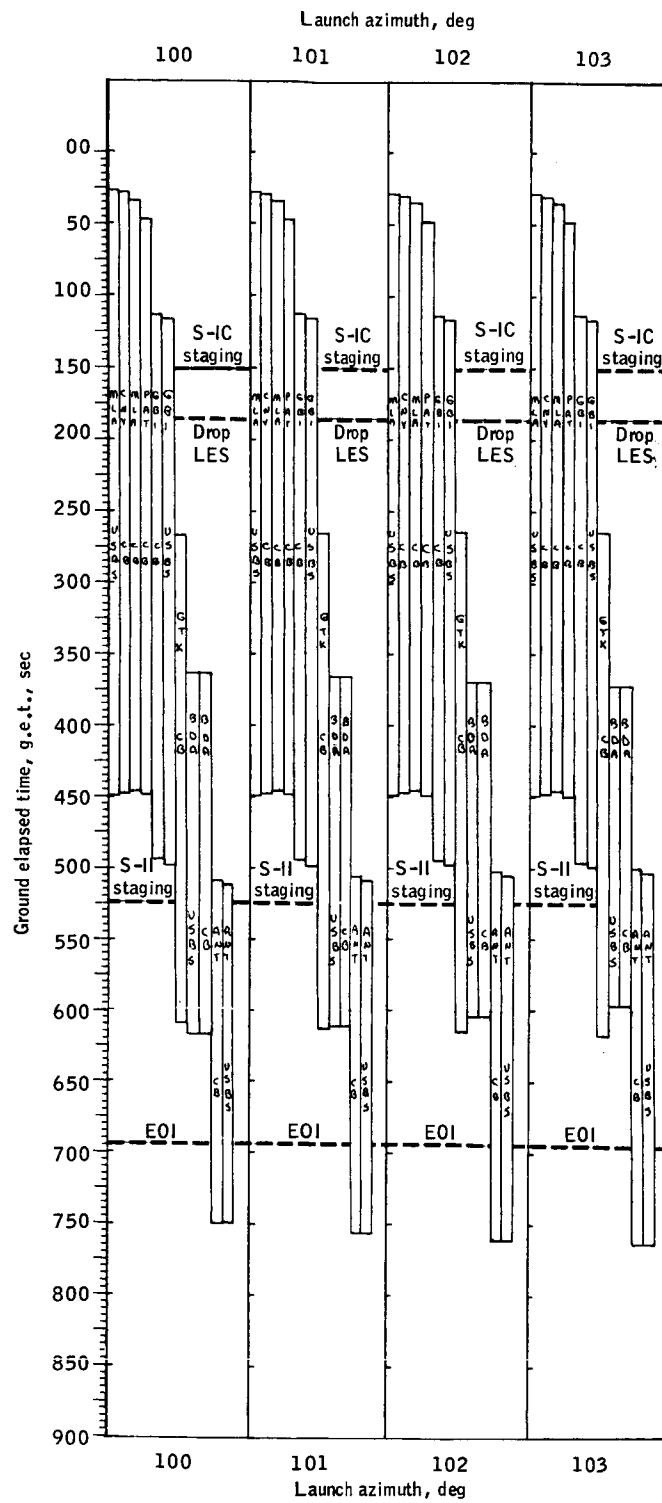
(f) Launch azimuths from 92 to 95 degrees.

Figure 1.- Continued.



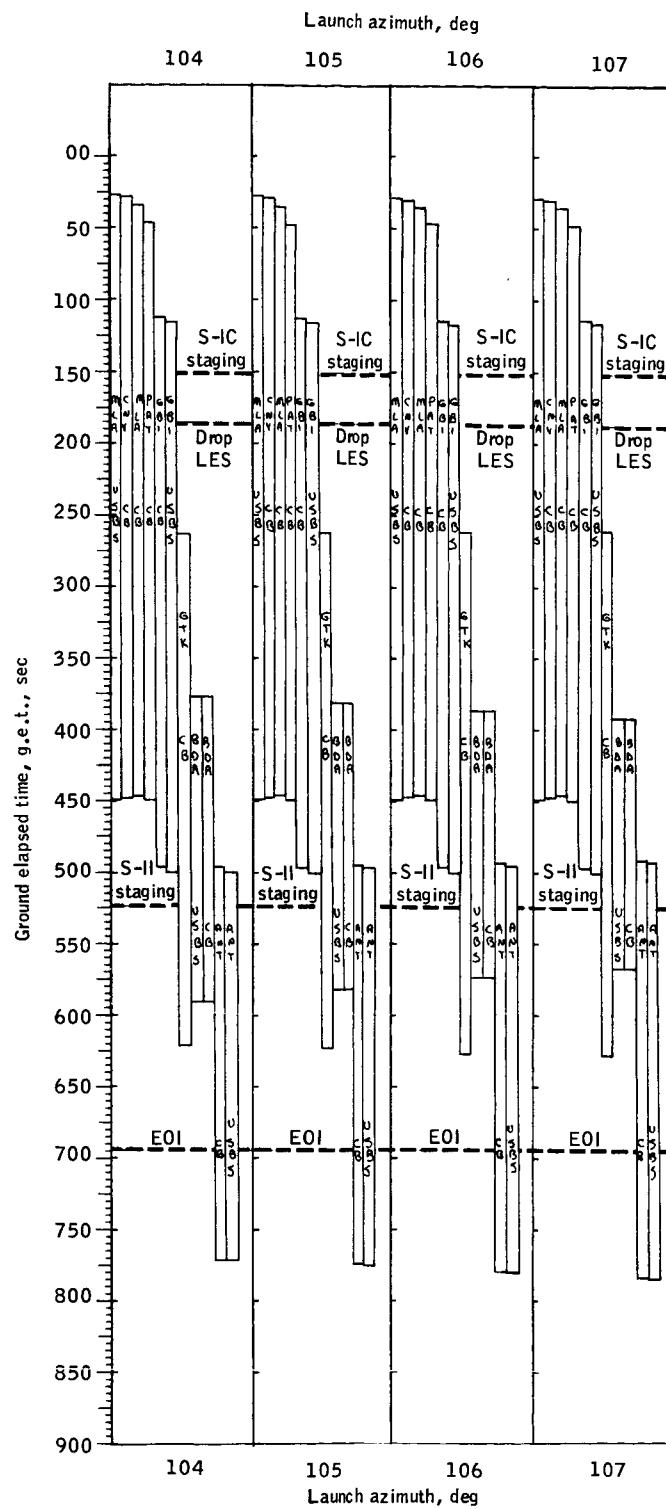
(g) Launch azimuths from 96 to 99 degrees.

Figure 1.- Continued.



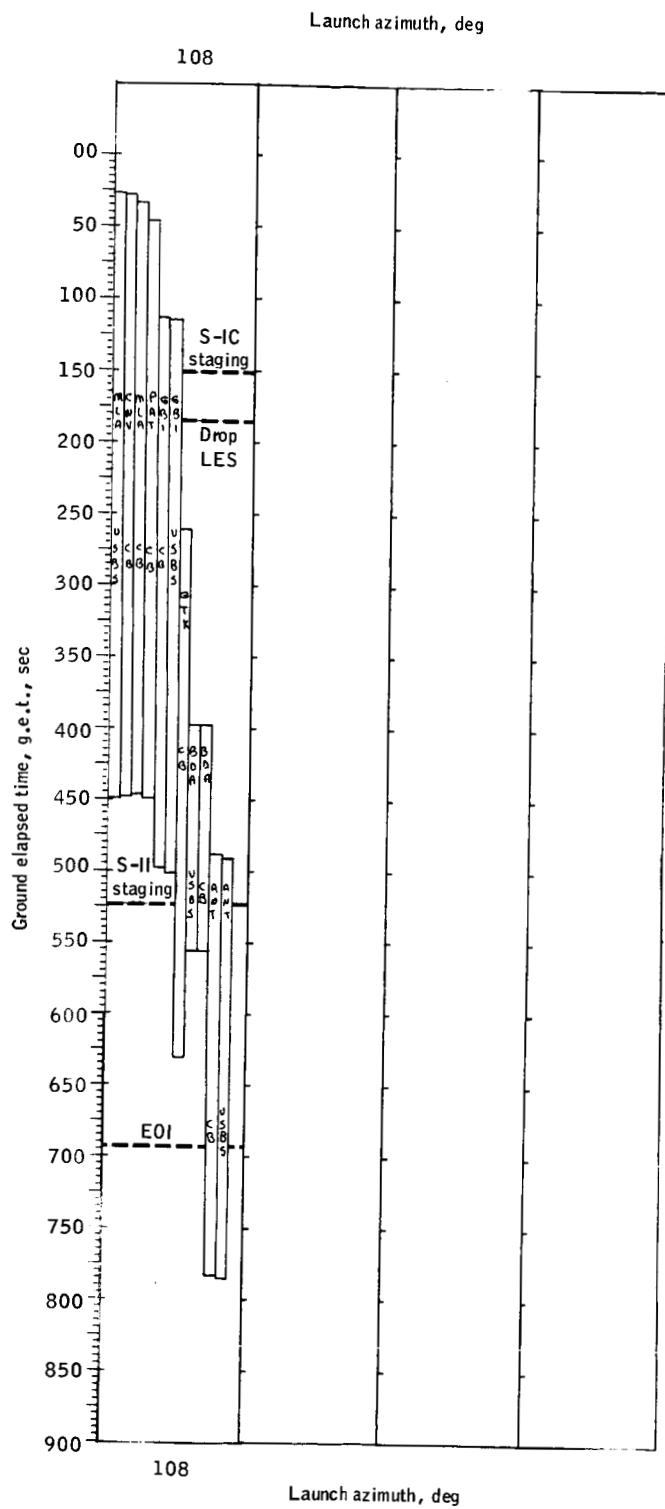
(h) Launch azimuths from 100 to 103 degrees.

Figure 1.- Continued.



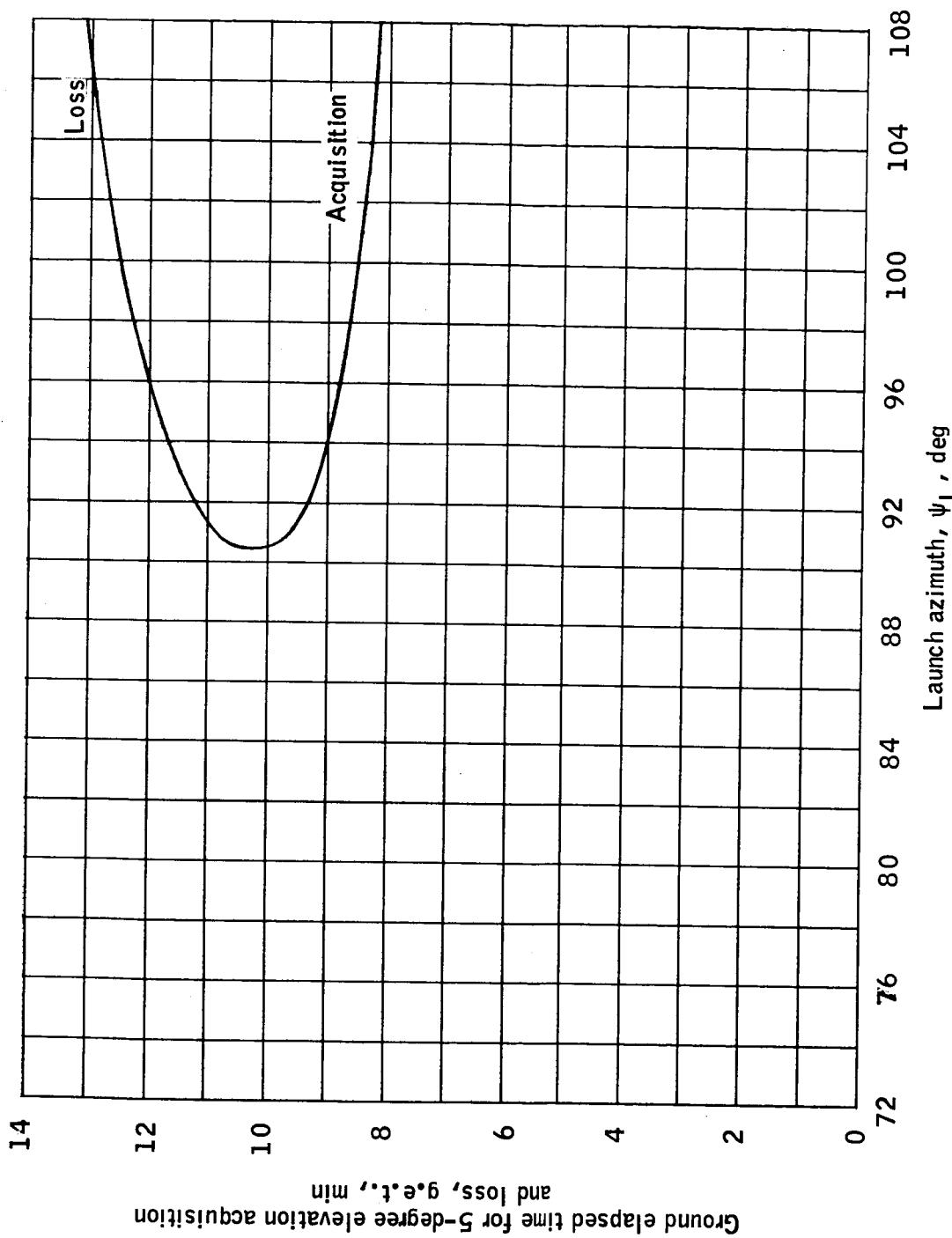
(i) Launch azimuths from 104 to 107 degrees.

Figure 1.- Continued.



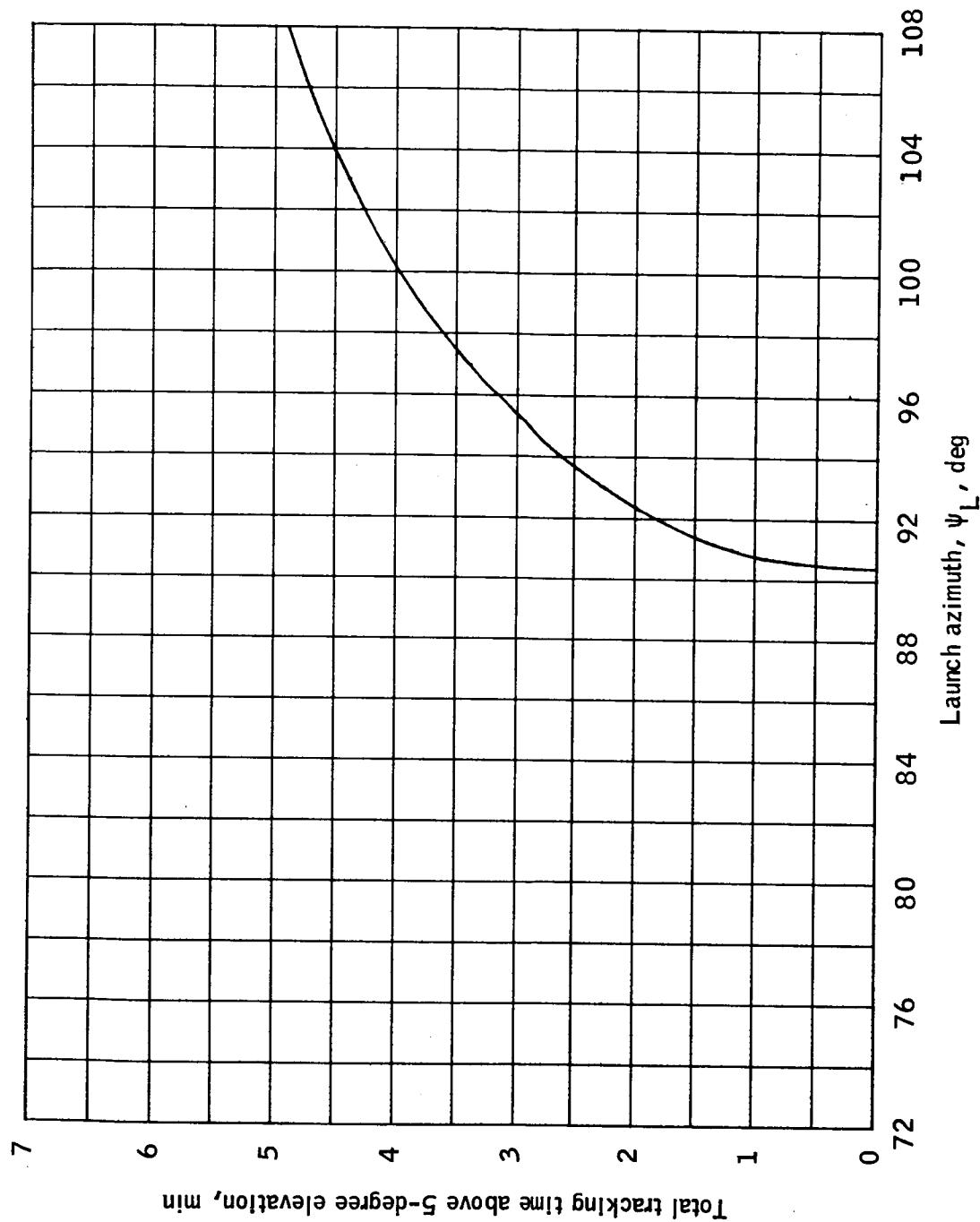
(j) Launch azimuth of 108 degrees.

Figure 1.- Concluded.



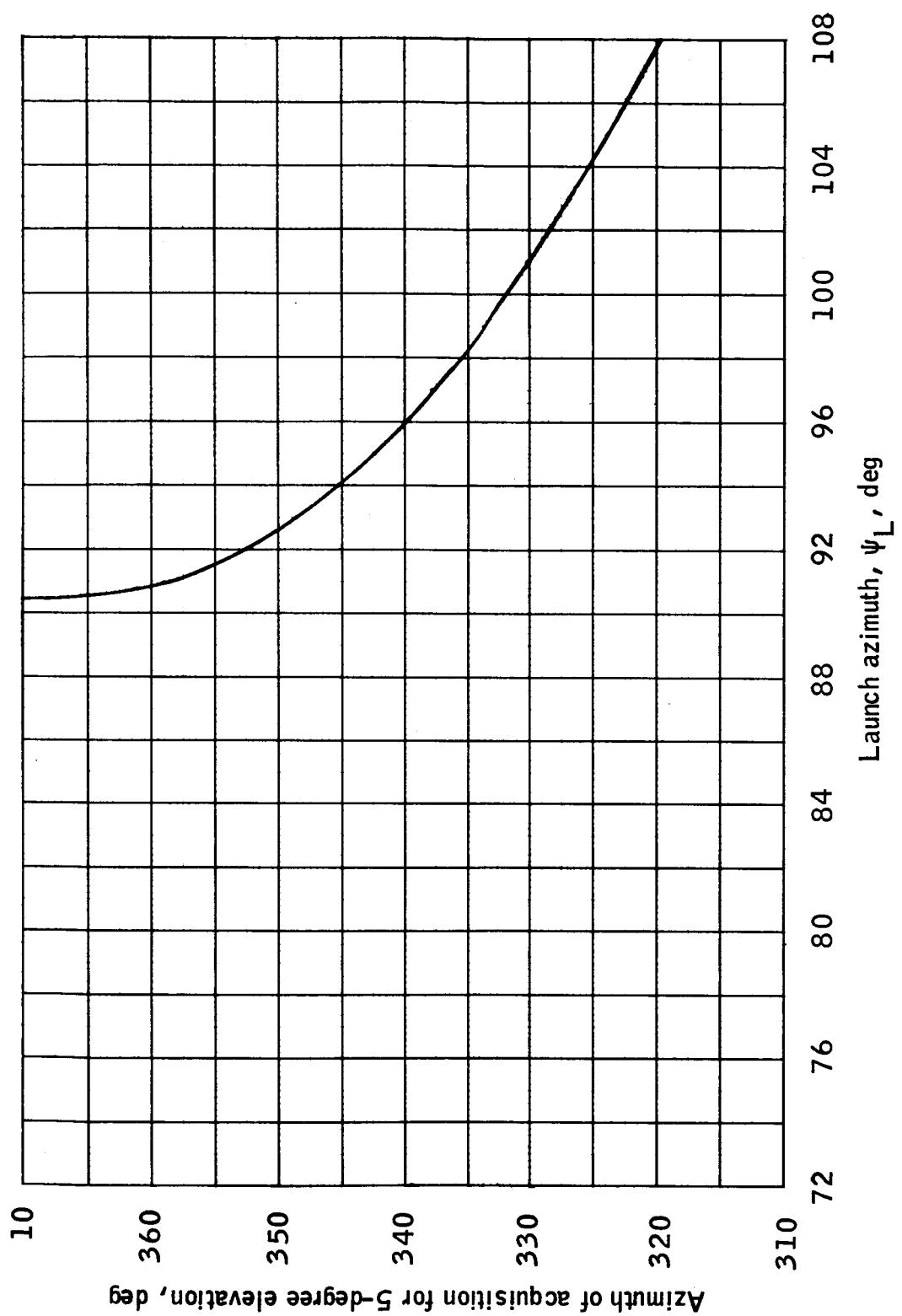
(a) Ground elapsed time for 5-degree acquisition and loss.

Figure 2.- Antigua USBS radar tracking information for the first 15 minutes after launch as a function of launch azimuth.



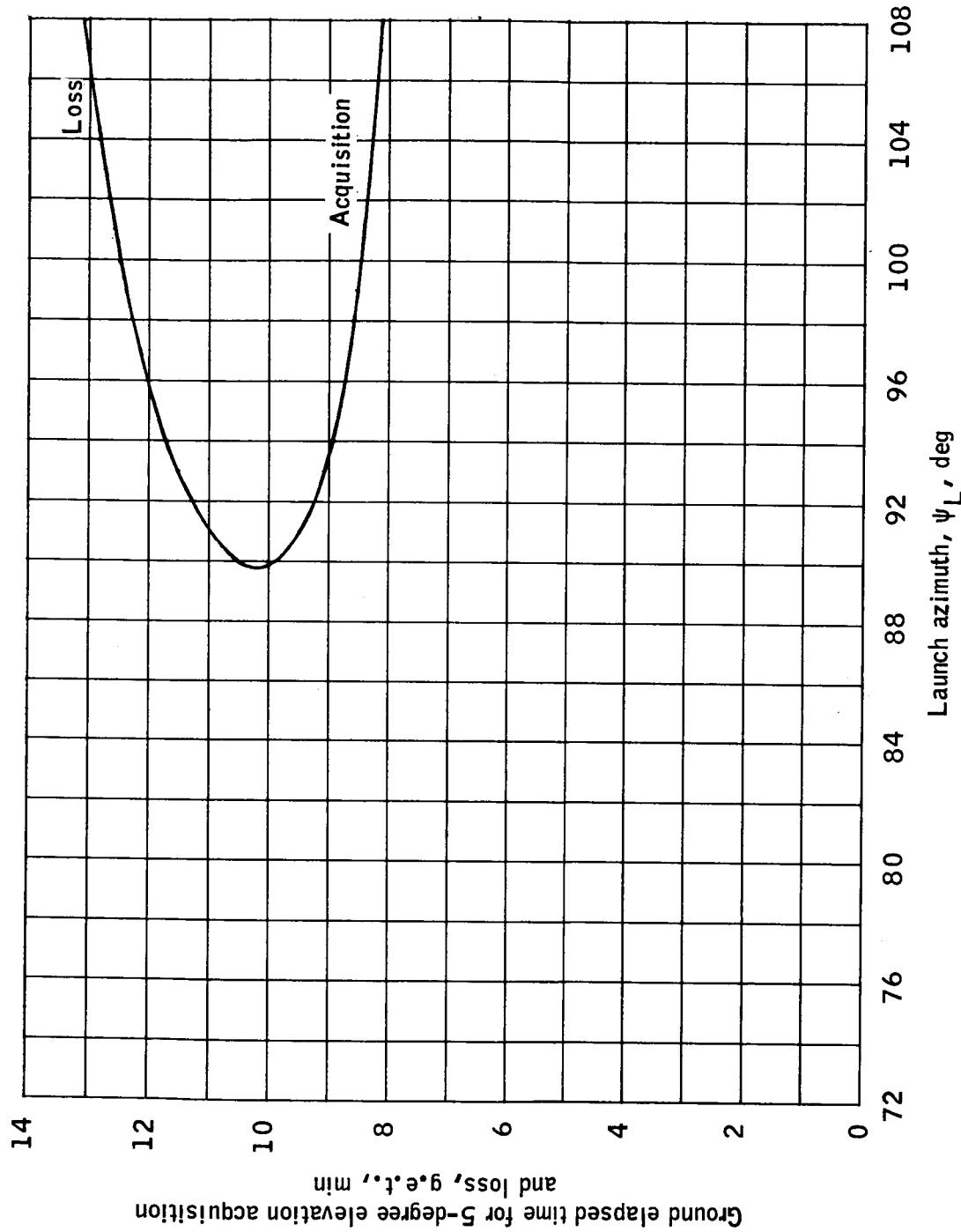
(b) Total tracking time above 5-degree elevation.

Figure 2. - Continued.



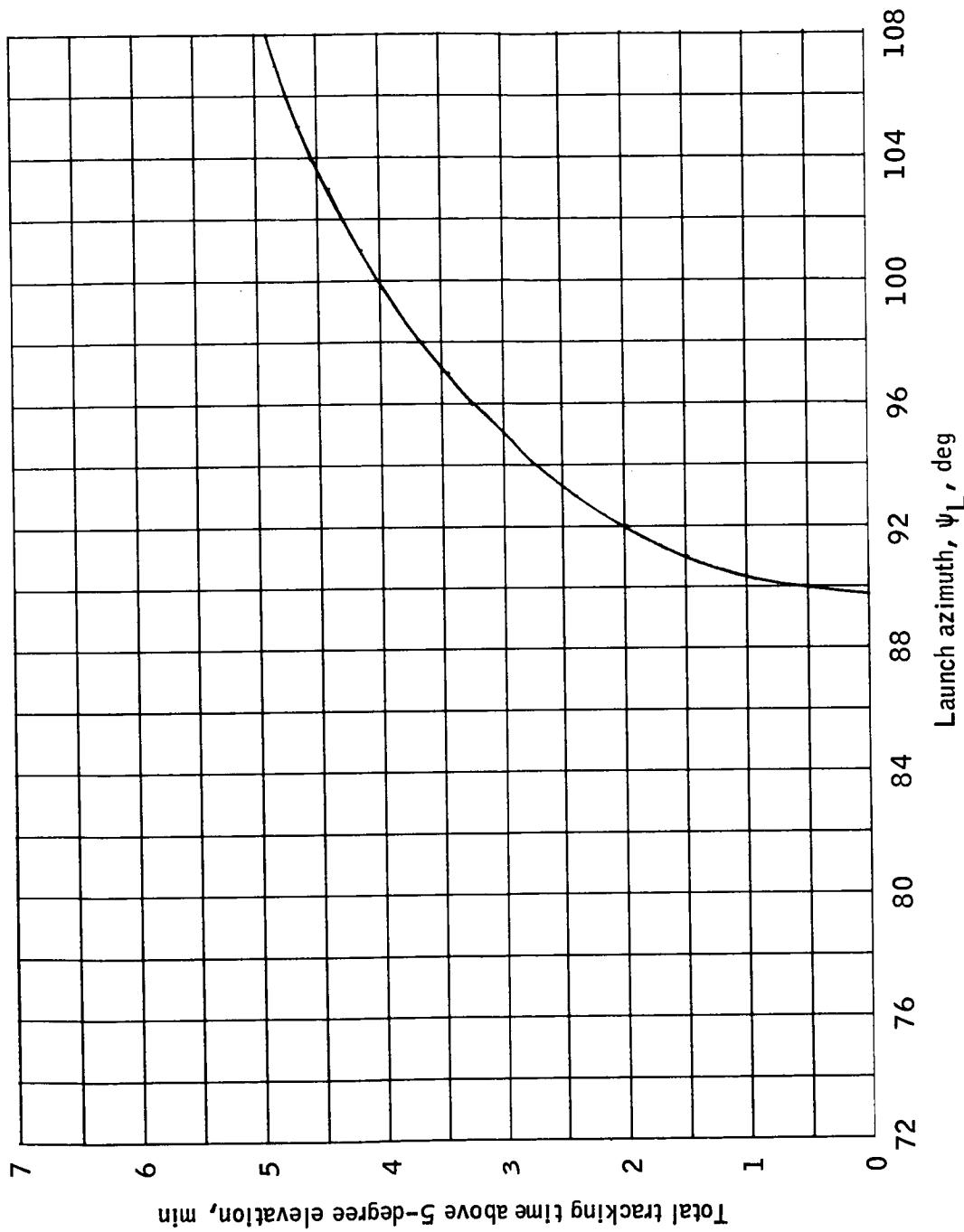
(c) Azimuth of acquisition for 5-degree elevation.

Figure 2 . - Concluded.



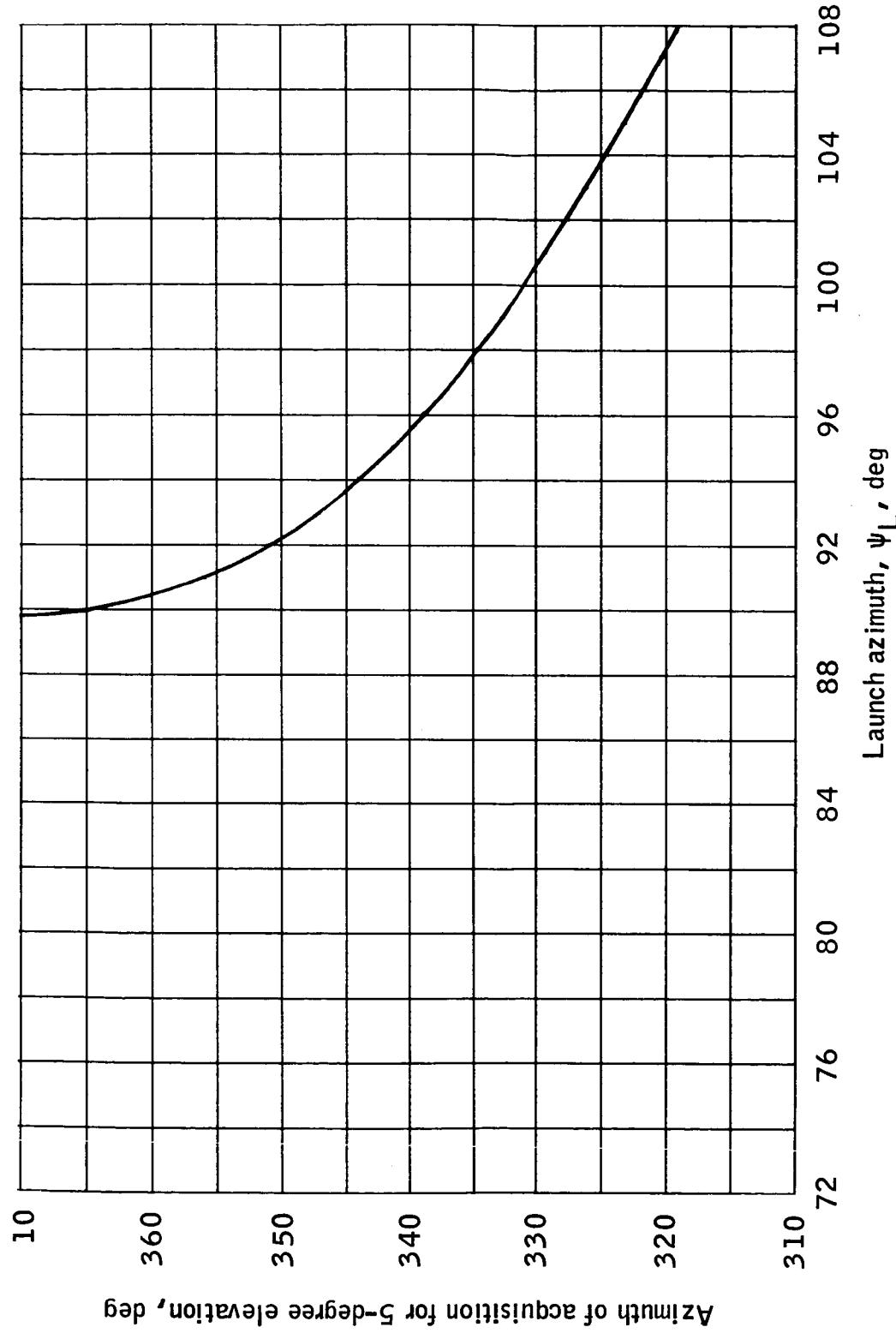
(a) Ground elapsed time for 5-degree acquisition and loss.

Figure 3.- Antigua C-band radar tracking information for the first 15 minutes after launch as a function of launch azimuth.



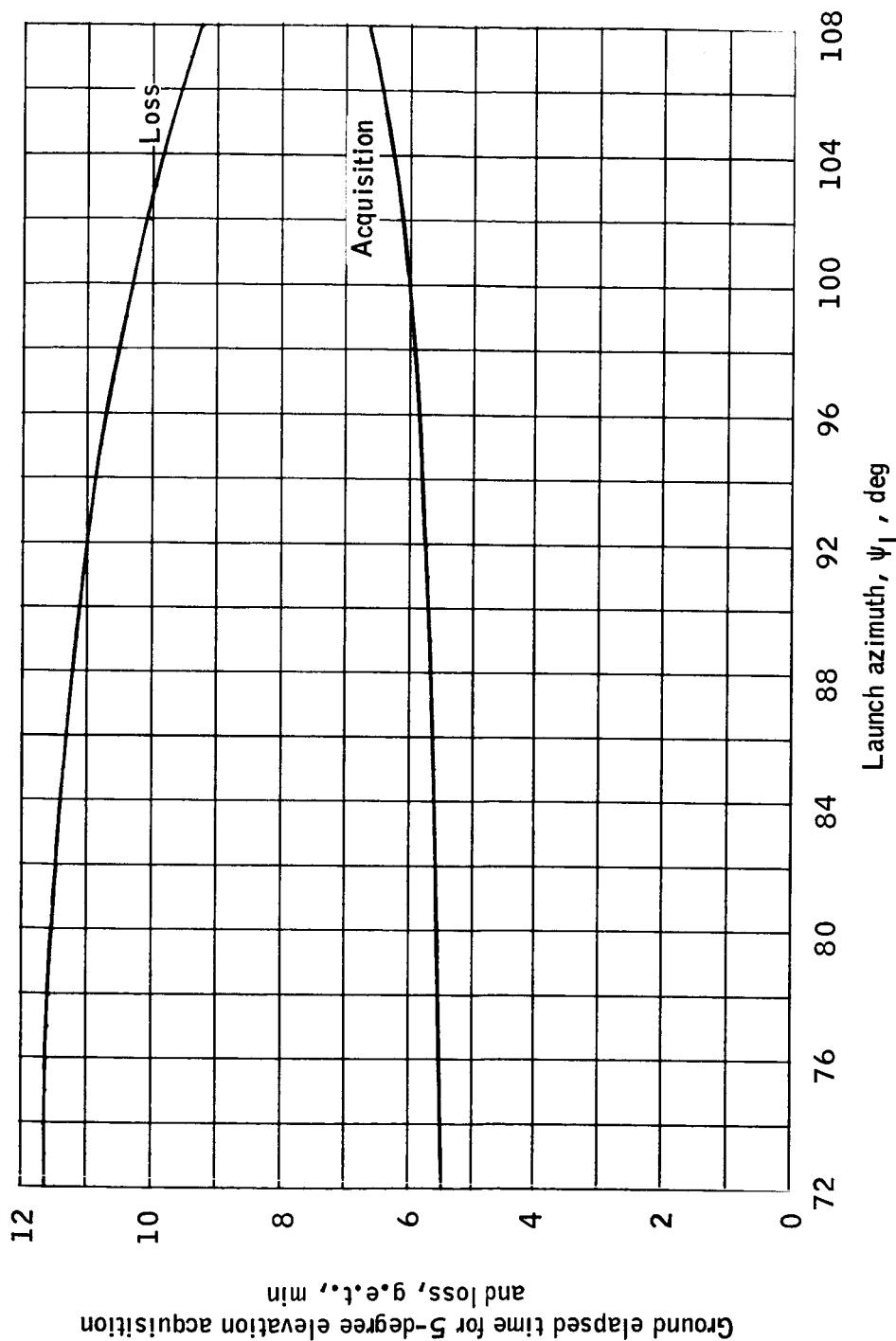
(b) Total tracking time above 5-degree elevation.

Figure 3.- Continued.



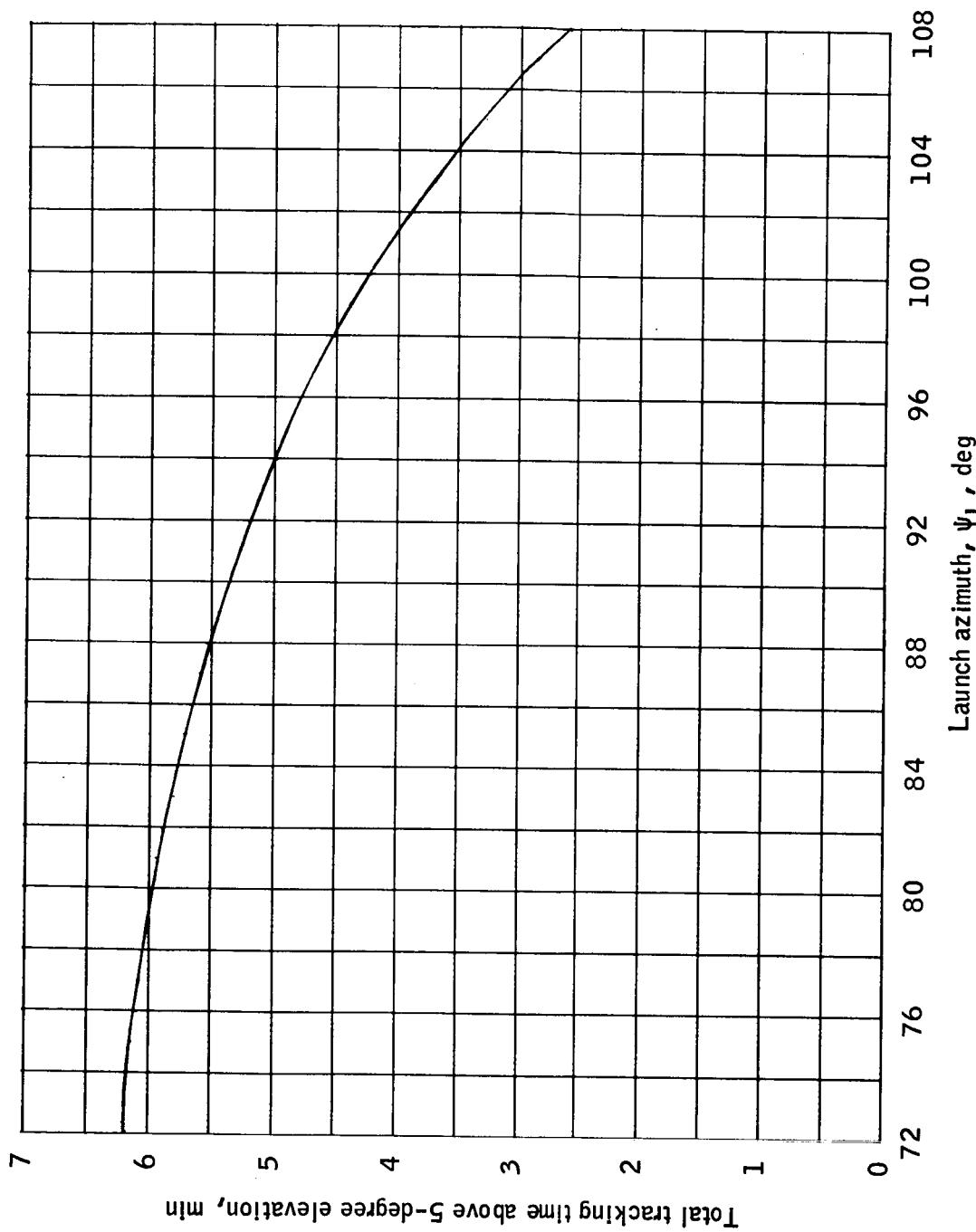
(c) Azimuth of acquisition for 5-degree elevation.

Figure 3.- Concluded.



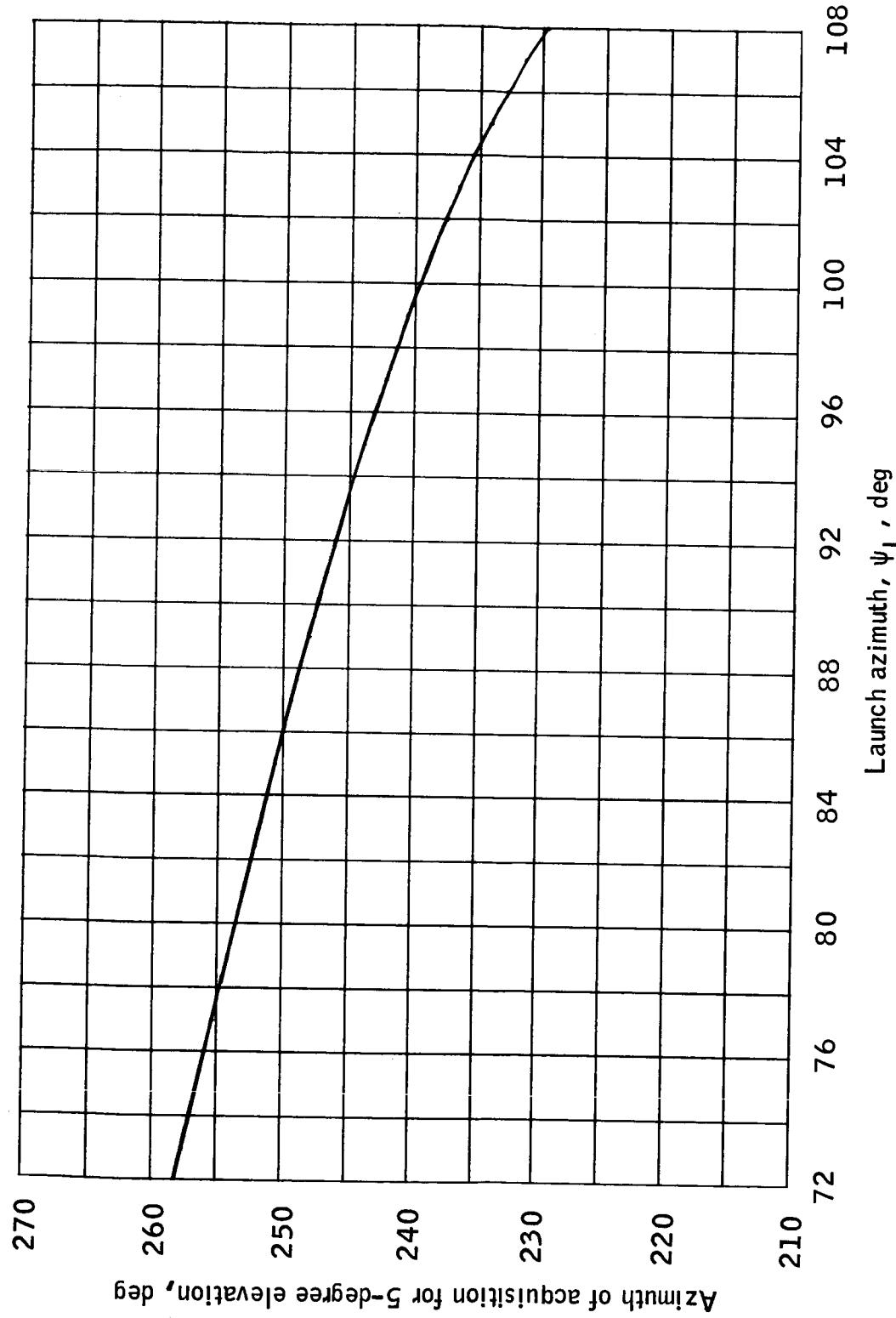
(a) Ground elapsed time for 5-degree acquisition and loss.

Figure 4.- Bermuda USBS radar tracking information for the first 15 minutes after launch as a function of launch azimuth.



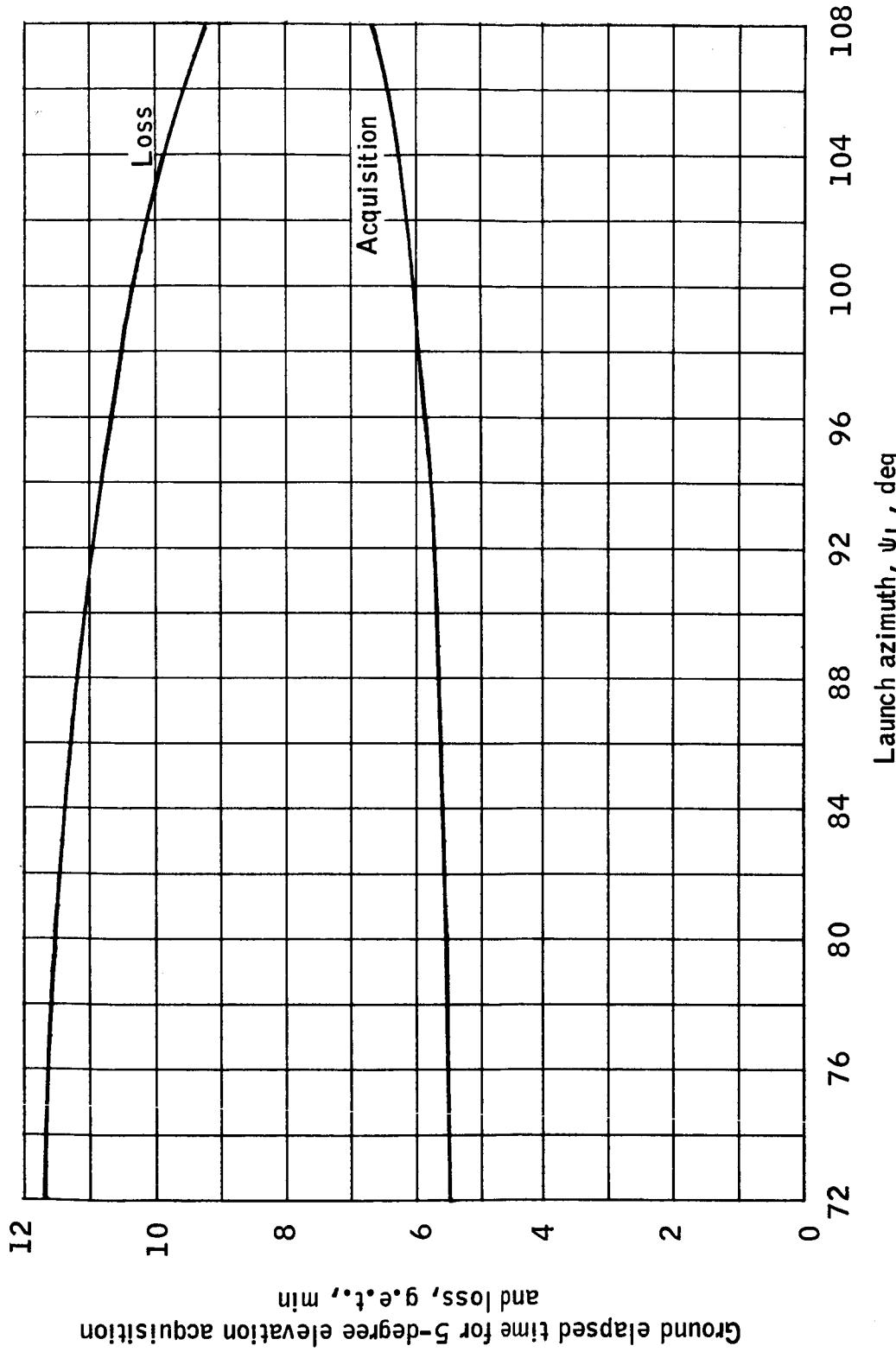
(b) Total tracking time above 5-degree elevation.

Figure 4.- Continued.



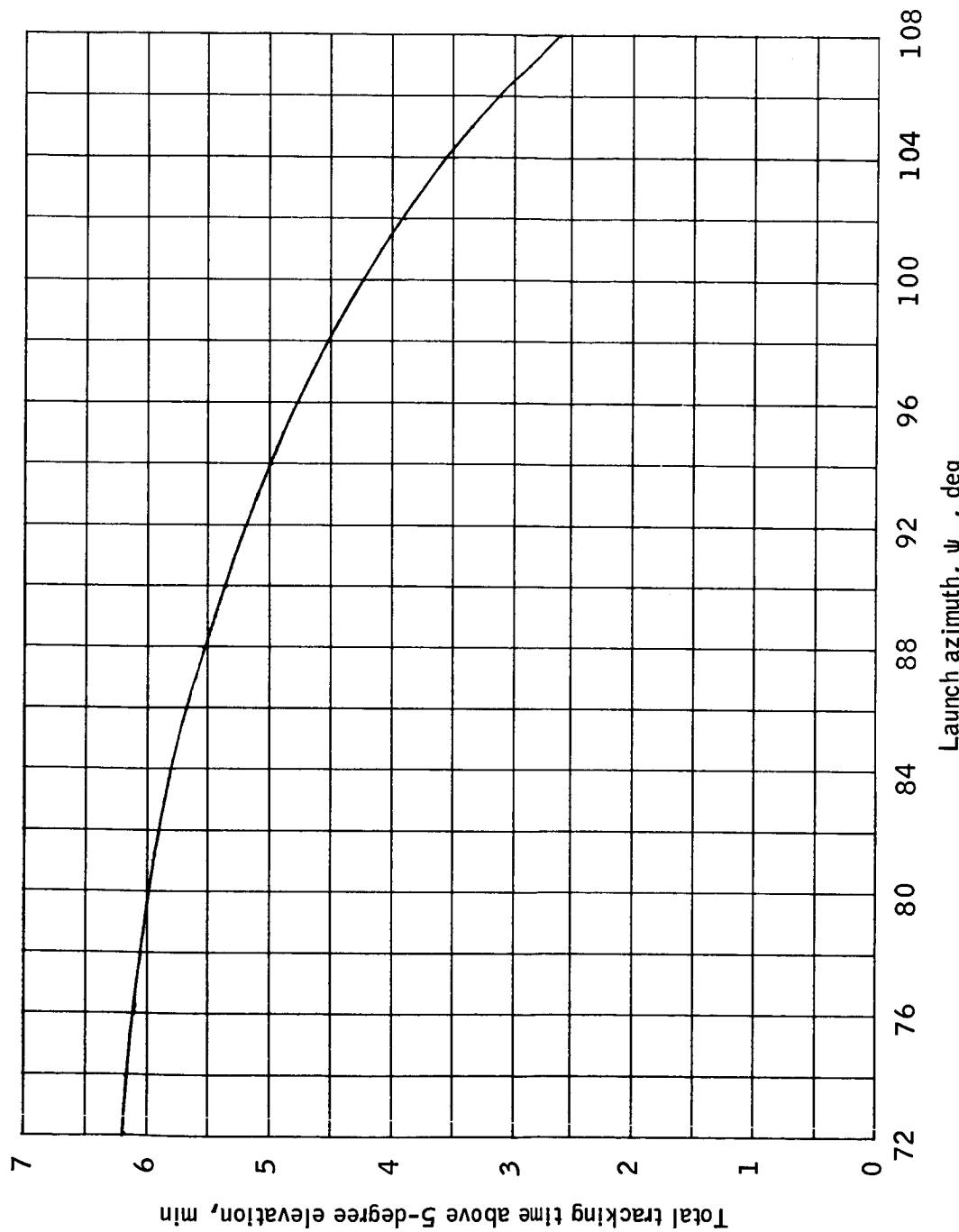
(c) Azimuth of acquisition for 5-degree elevation.

Figure 4. - Concluded.



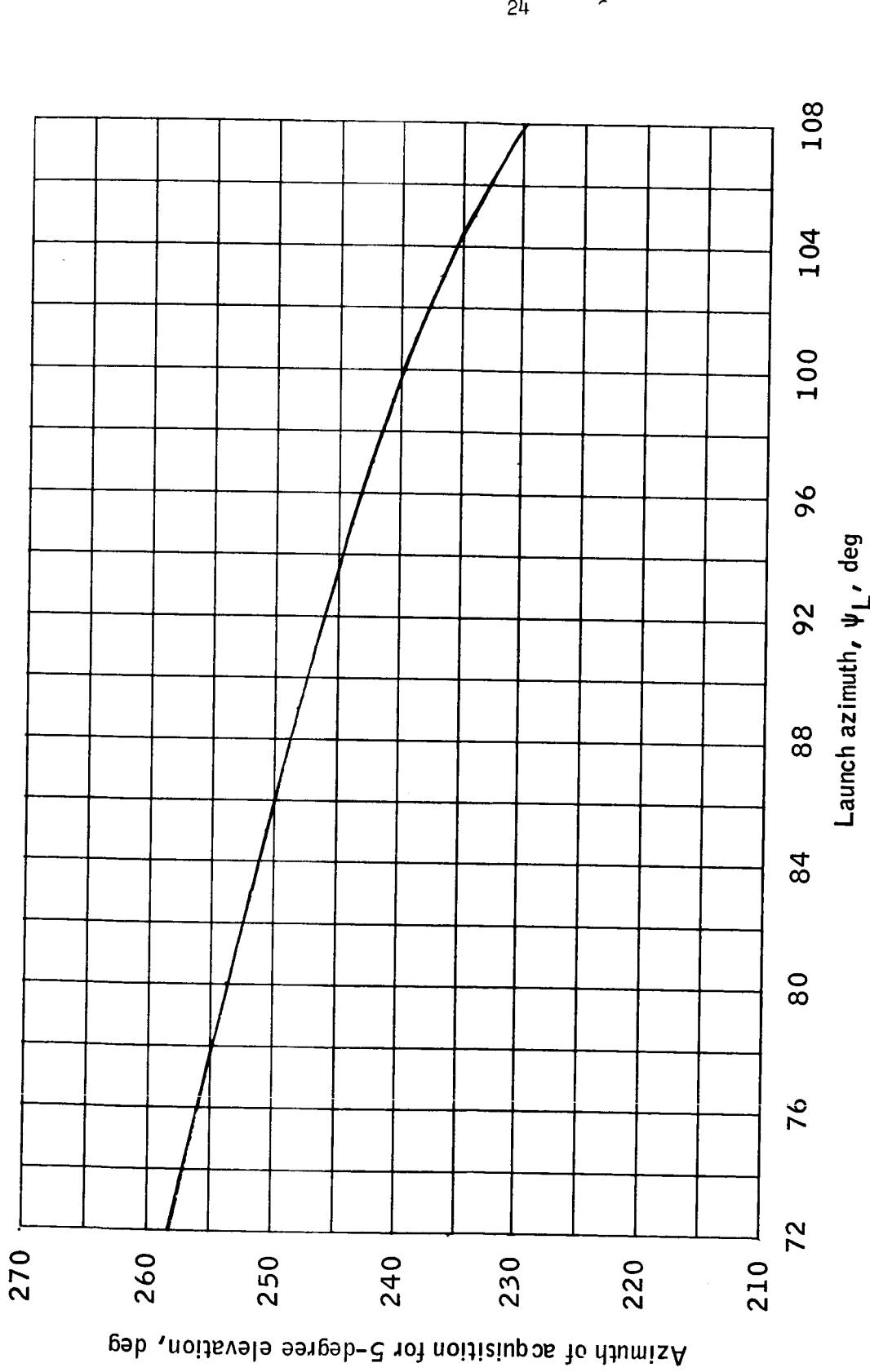
(a) Ground elapsed time for 5-degree acquisition and loss.

Figure 5.- Bermuda C-band radar tracking information for the first 15 minutes after launch as a function of launch azimuth.



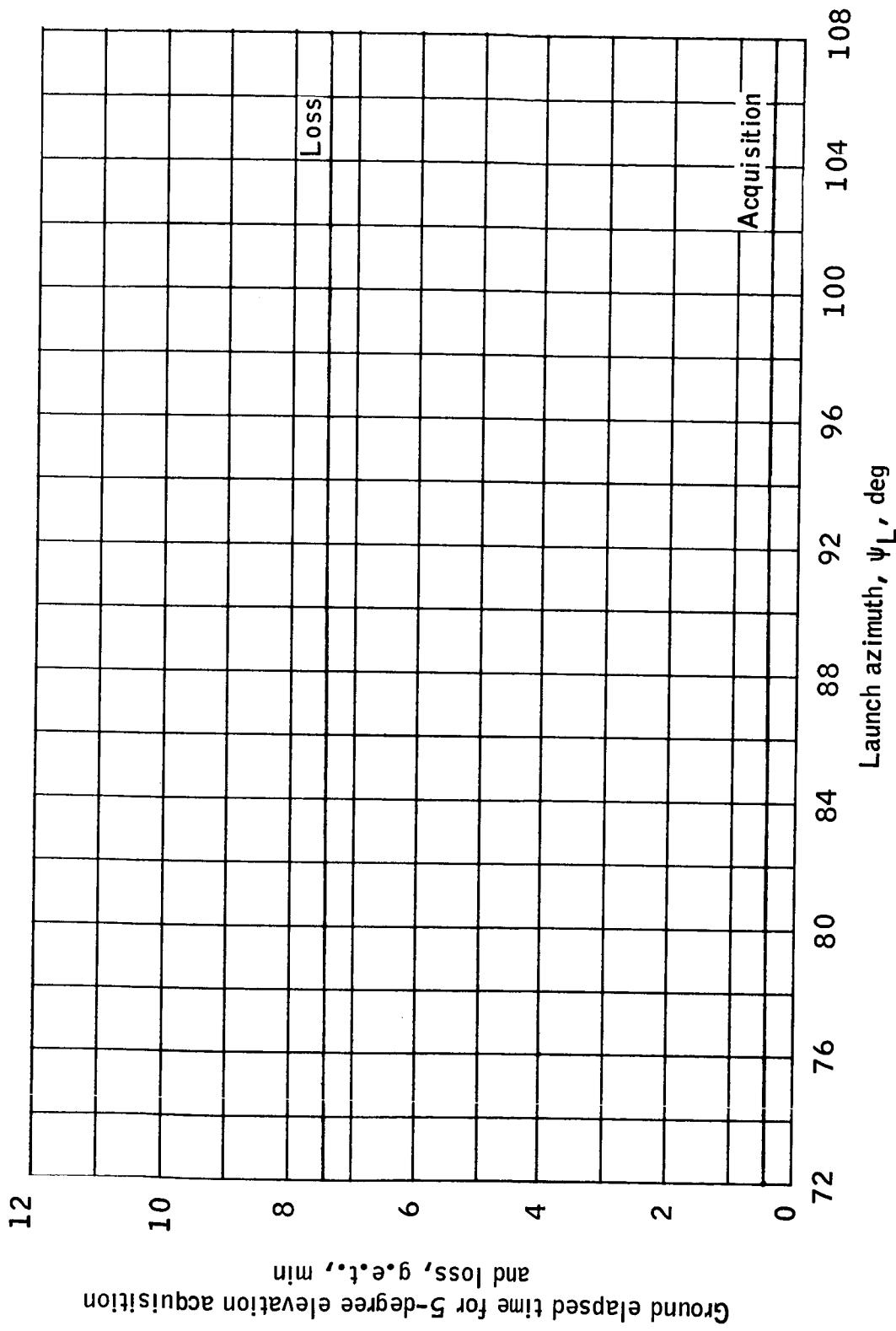
(b) Total tracking time above 5-degree elevation.

Figure 5.- Continued.



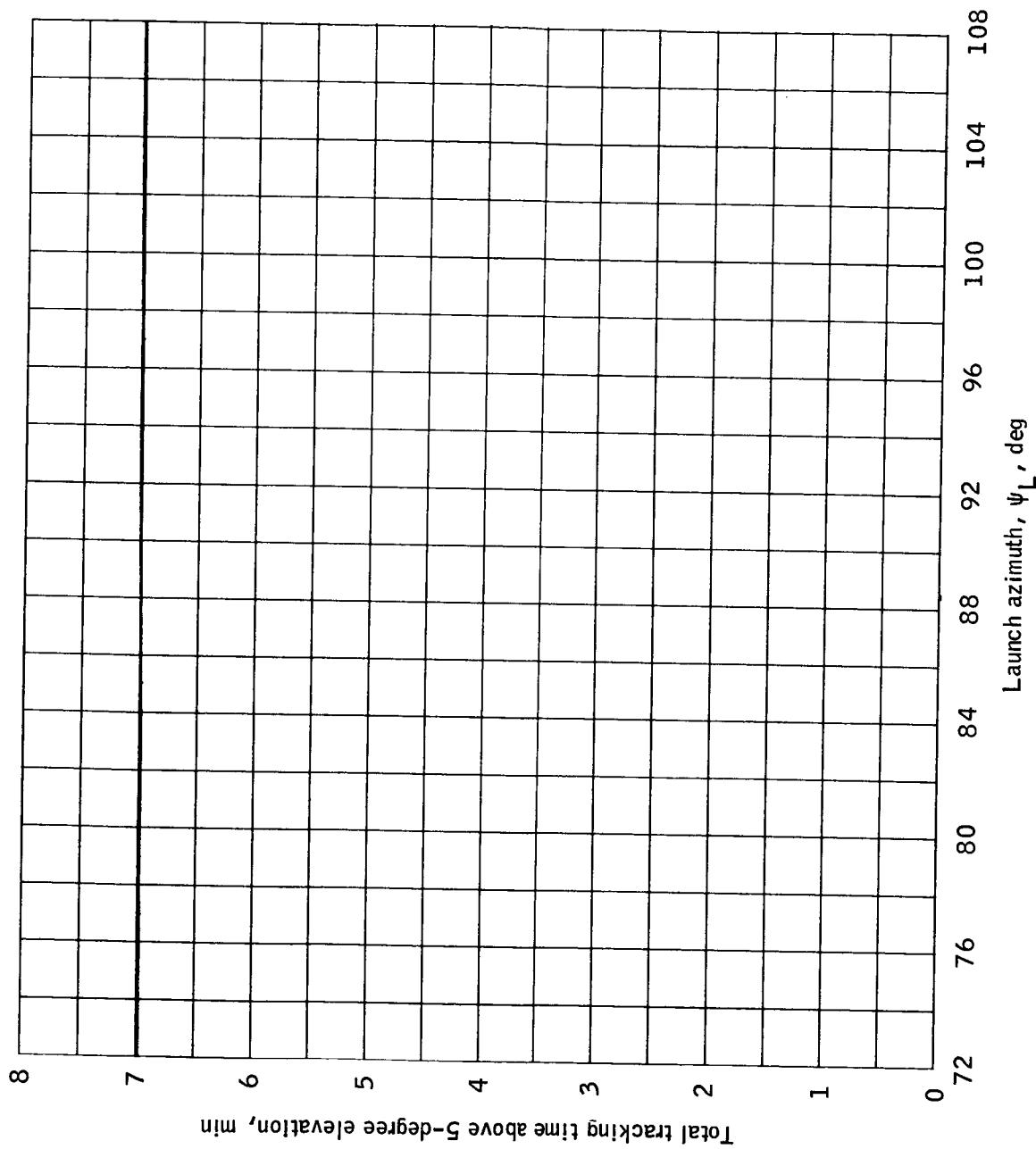
(c) Azimuth of acquisition for 5-degree elevation.

Figure 5.- Concluded.



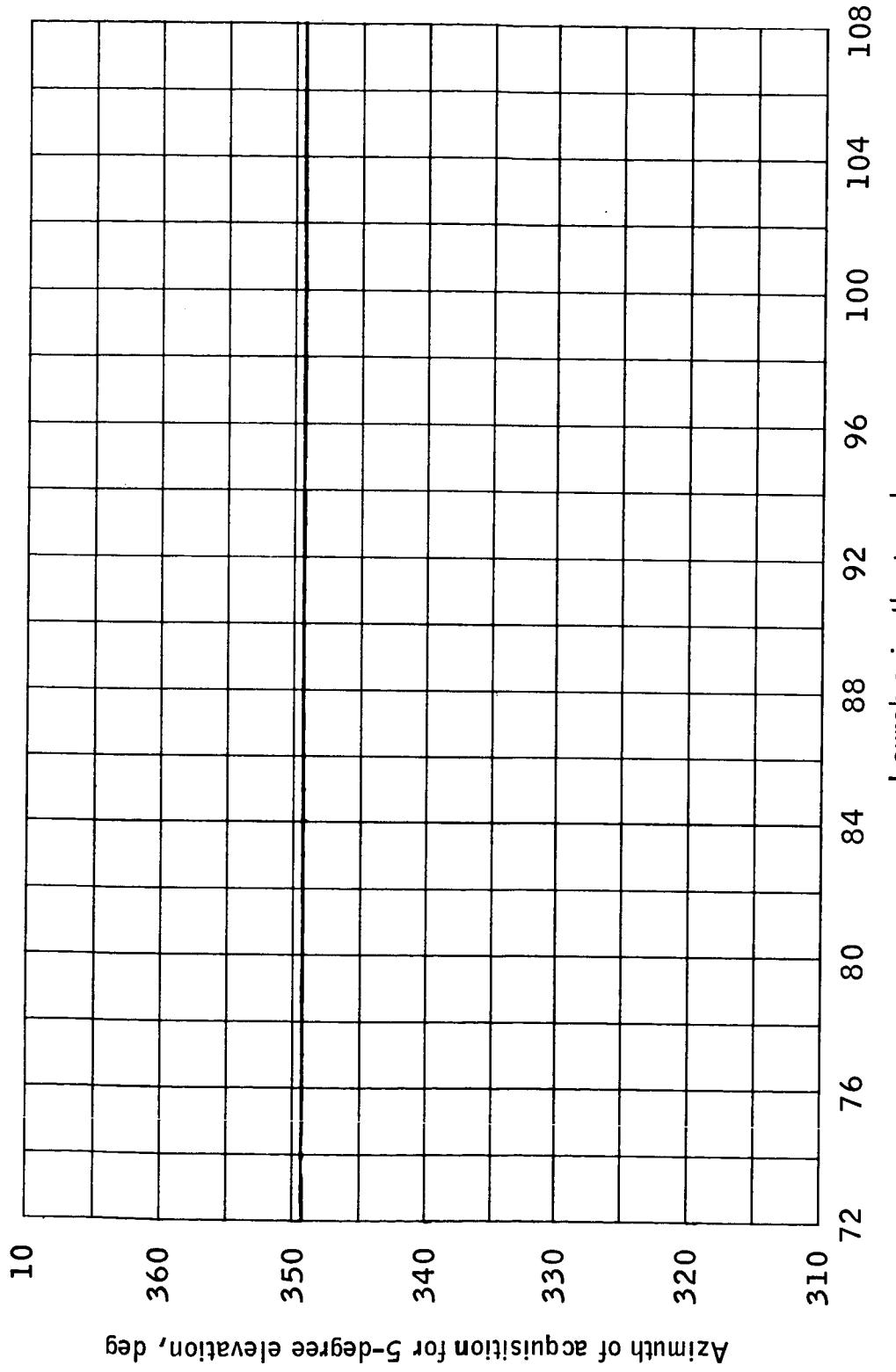
(a) Ground elapsed time for 5-degree acquisition and loss.

Figure 6.- Cape Kennedy C-band radar tracking information for the first 15 minutes after launch as a function of launch azimuth.



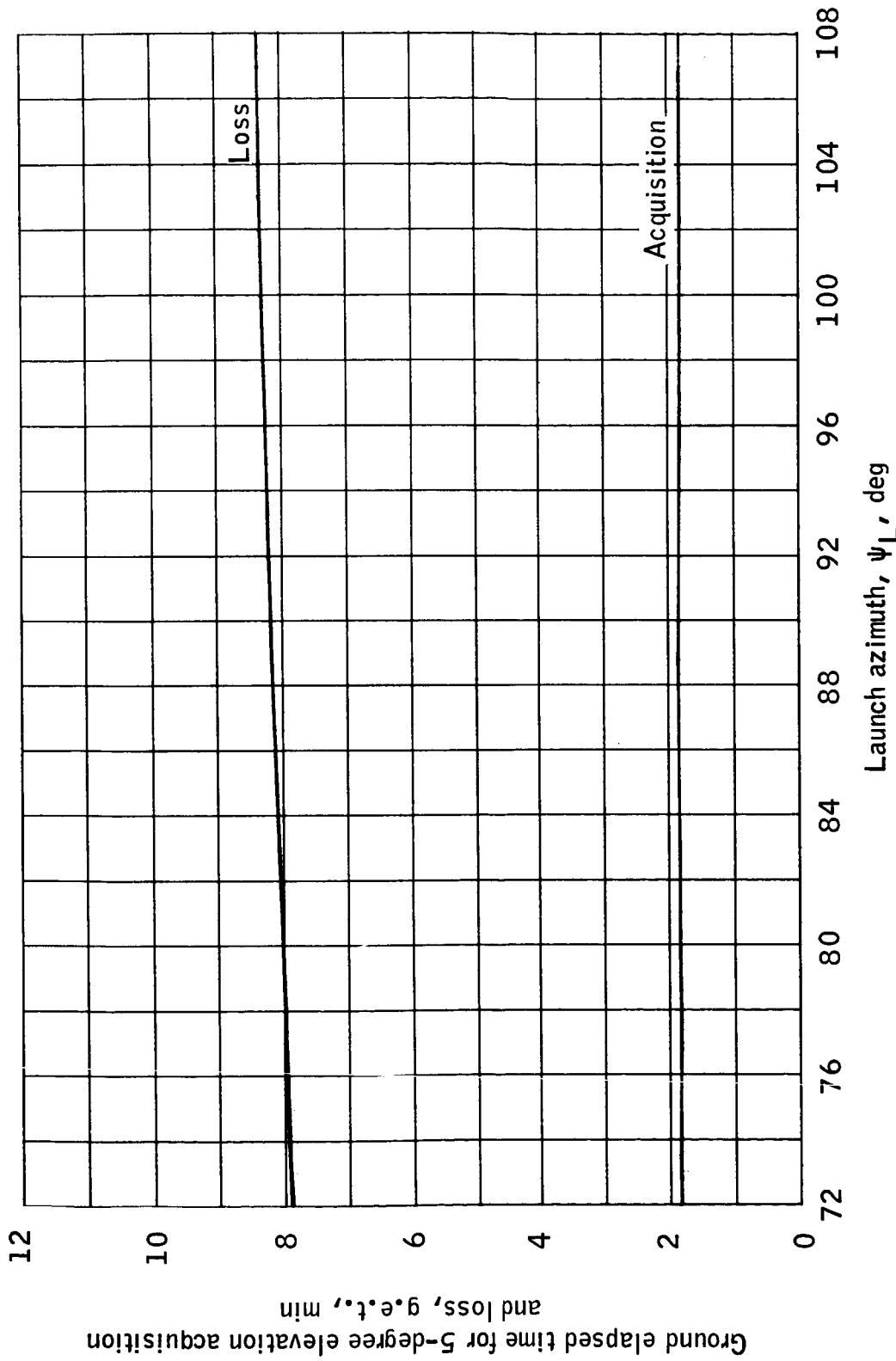
(b) Total tracking time above 5-degree elevation.

Figure 6. - Continued.



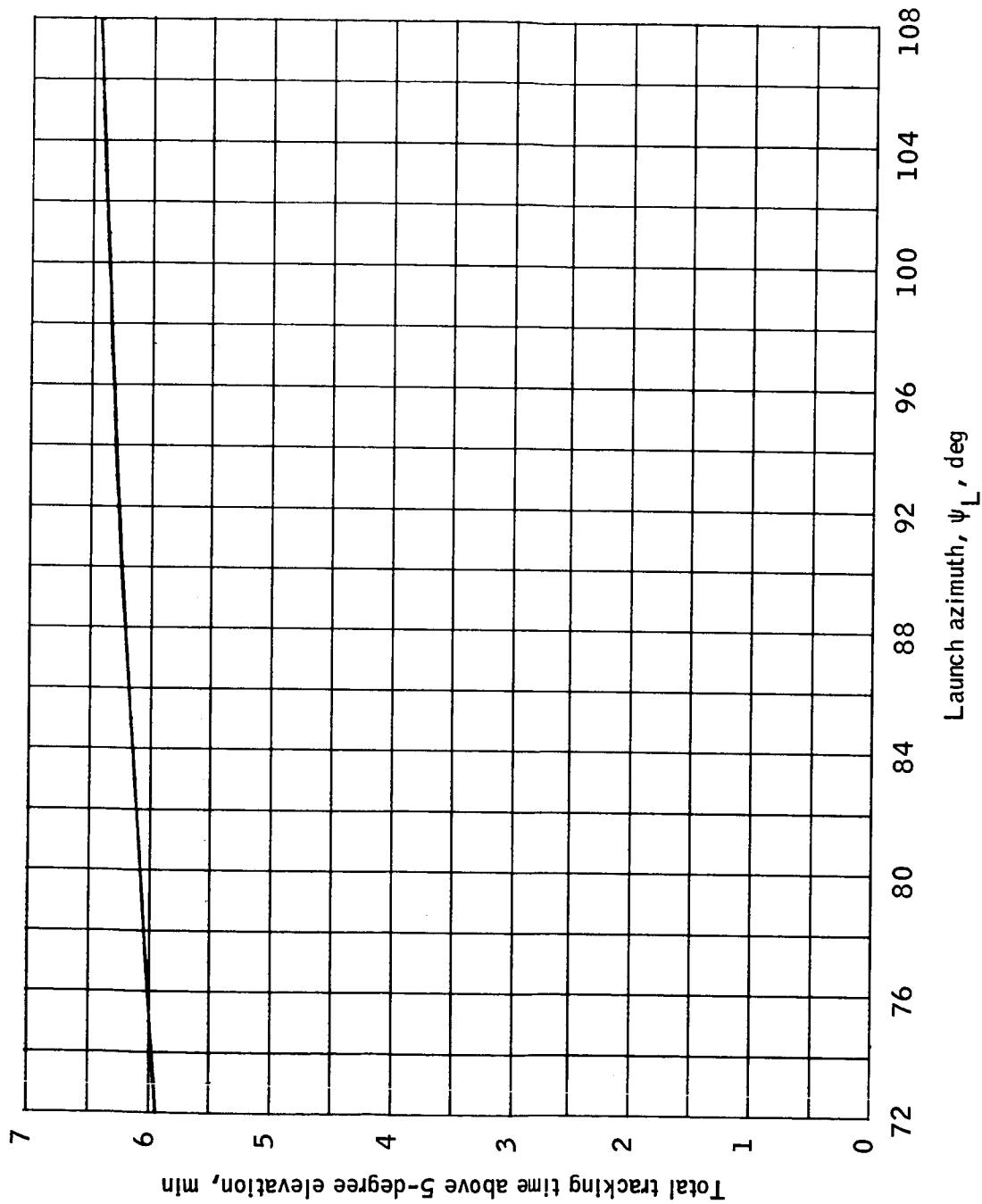
(c) Azimuth of acquisition for 5-degree elevation.

Figure 6.- Concluded.



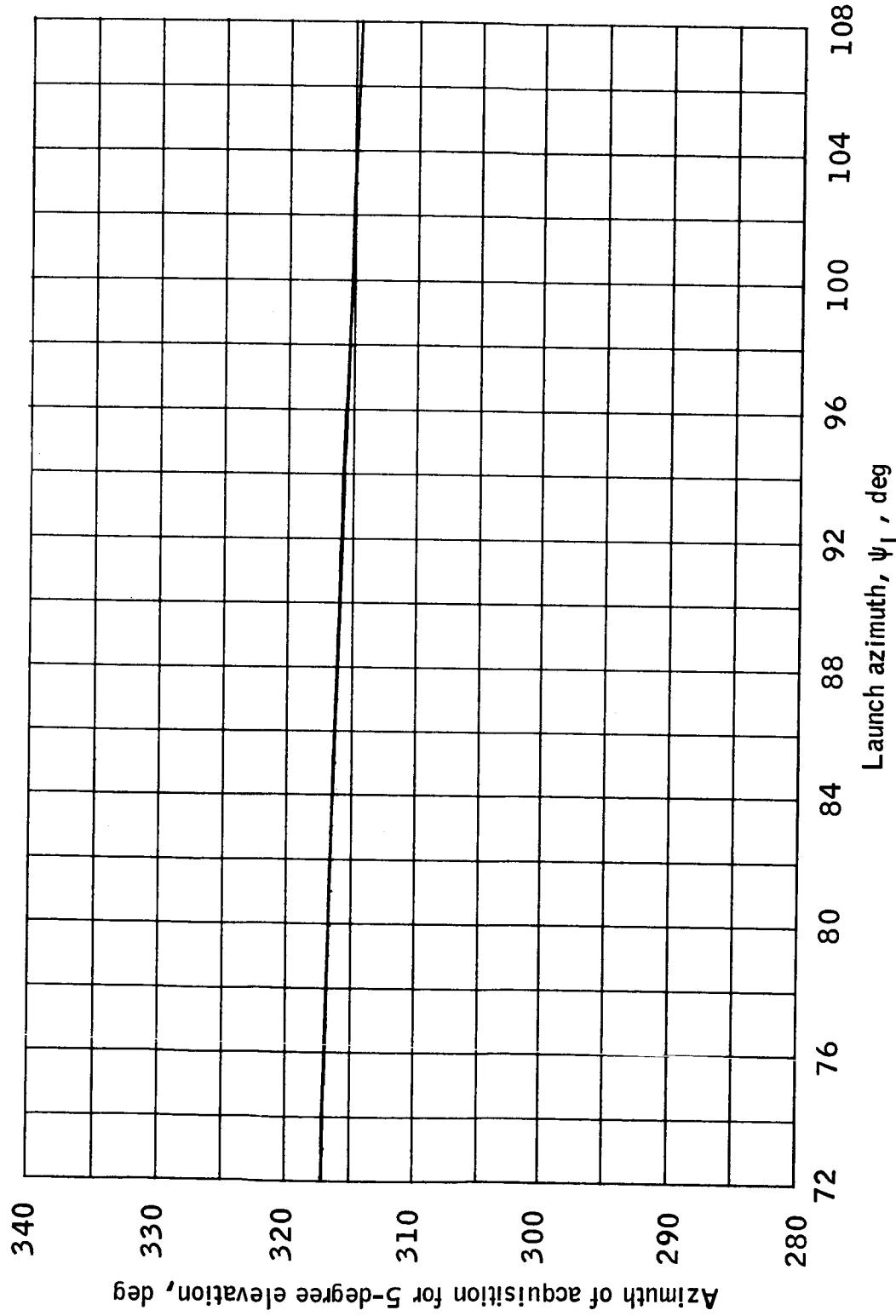
(a) Ground elapsed time for 5-degree acquisition and loss.

Figure 7.- Grand Bahama Island USBS radar tracking information for the first 15 minutes after launch as a function of launch azimuth.



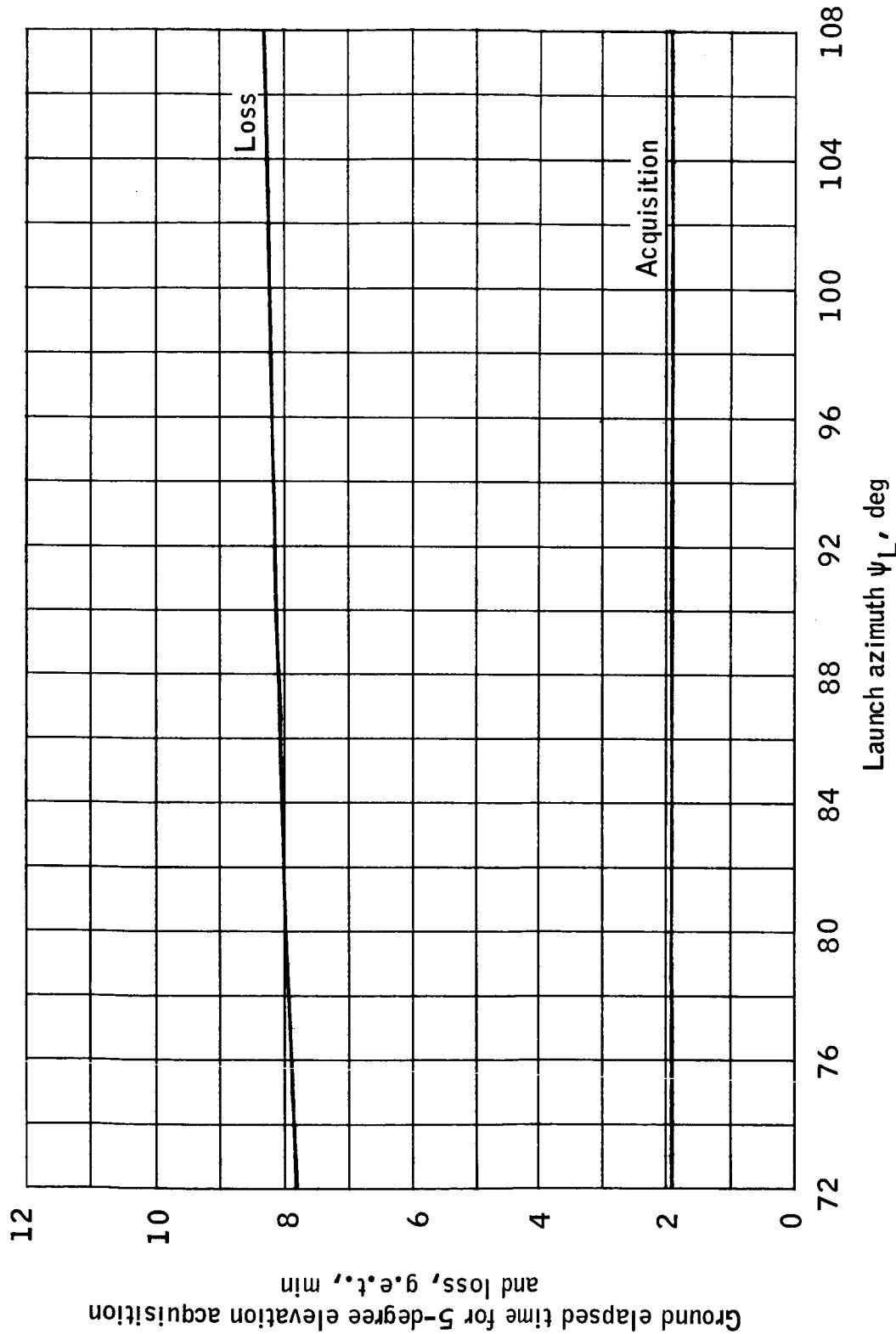
(b) Total tracking time above 5-degree elevation.

Figure 7.- Continued.



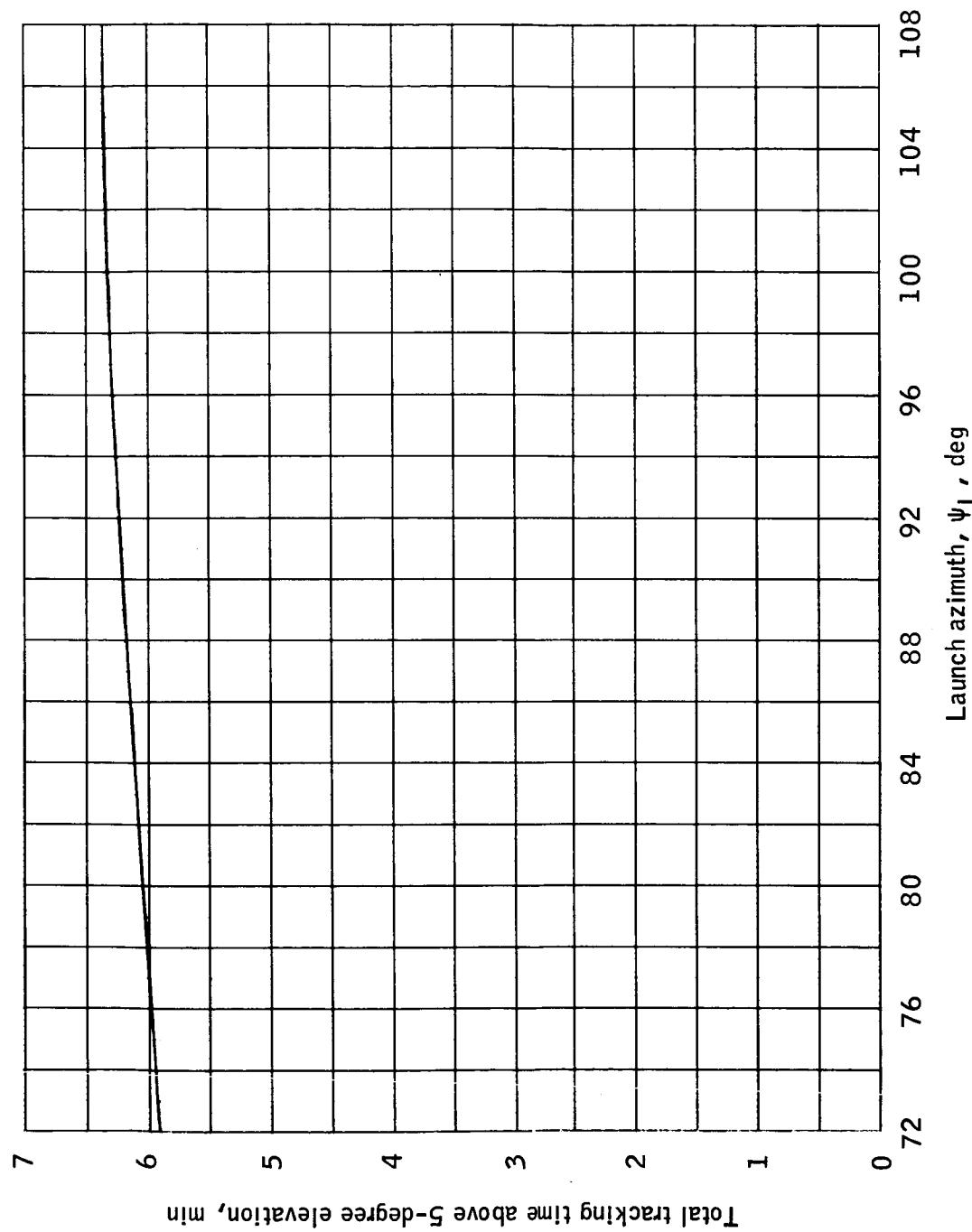
(c) Azimuth of acquisition for 5-degree elevation.

Figure 7 . - Concluded.



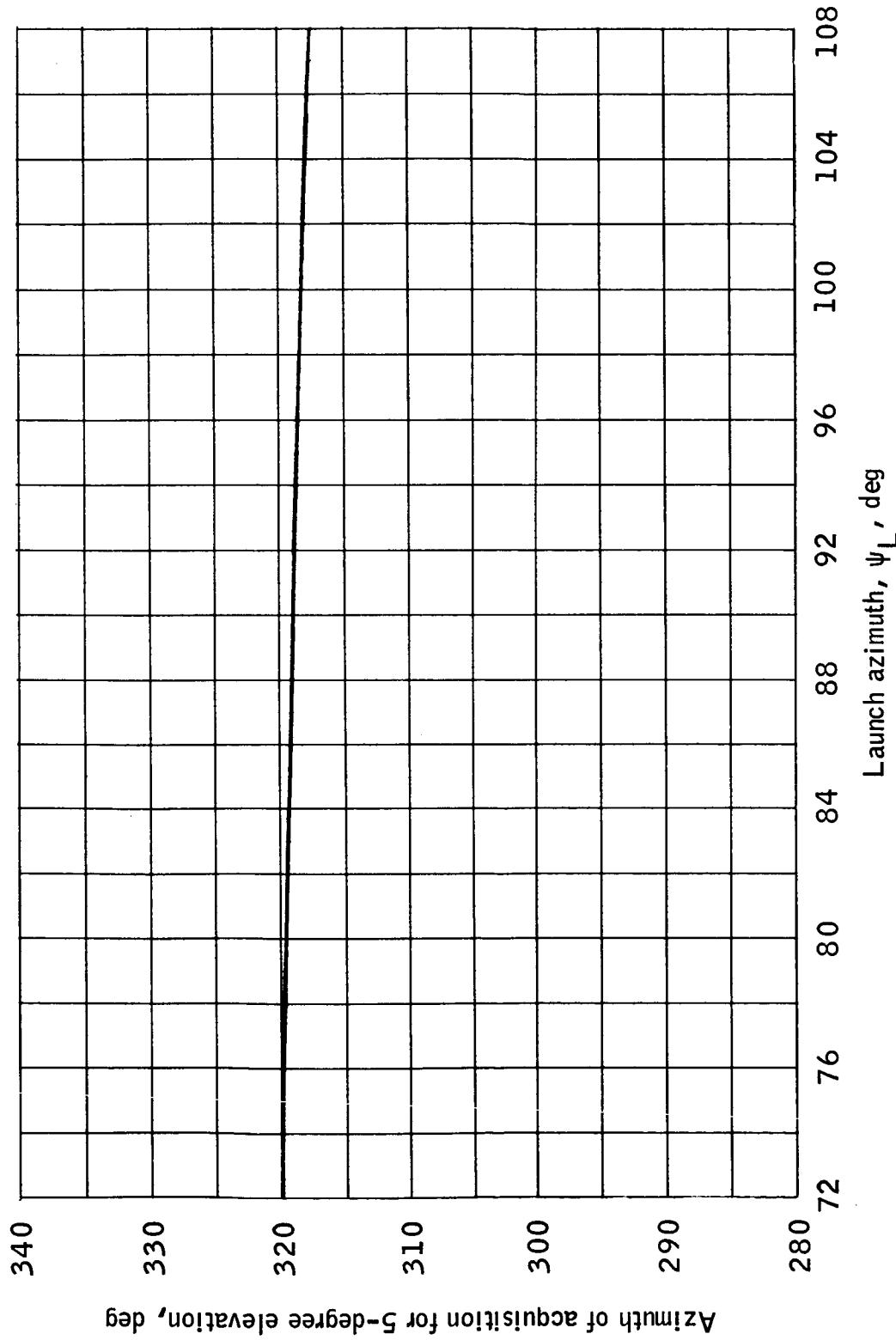
(a) Ground elapsed time for 5-degree acquisition and loss.

Figure 8.— Grand Bahama Island C-band radar tracking information for the first 15 minutes after launch as a function of launch azimuth.



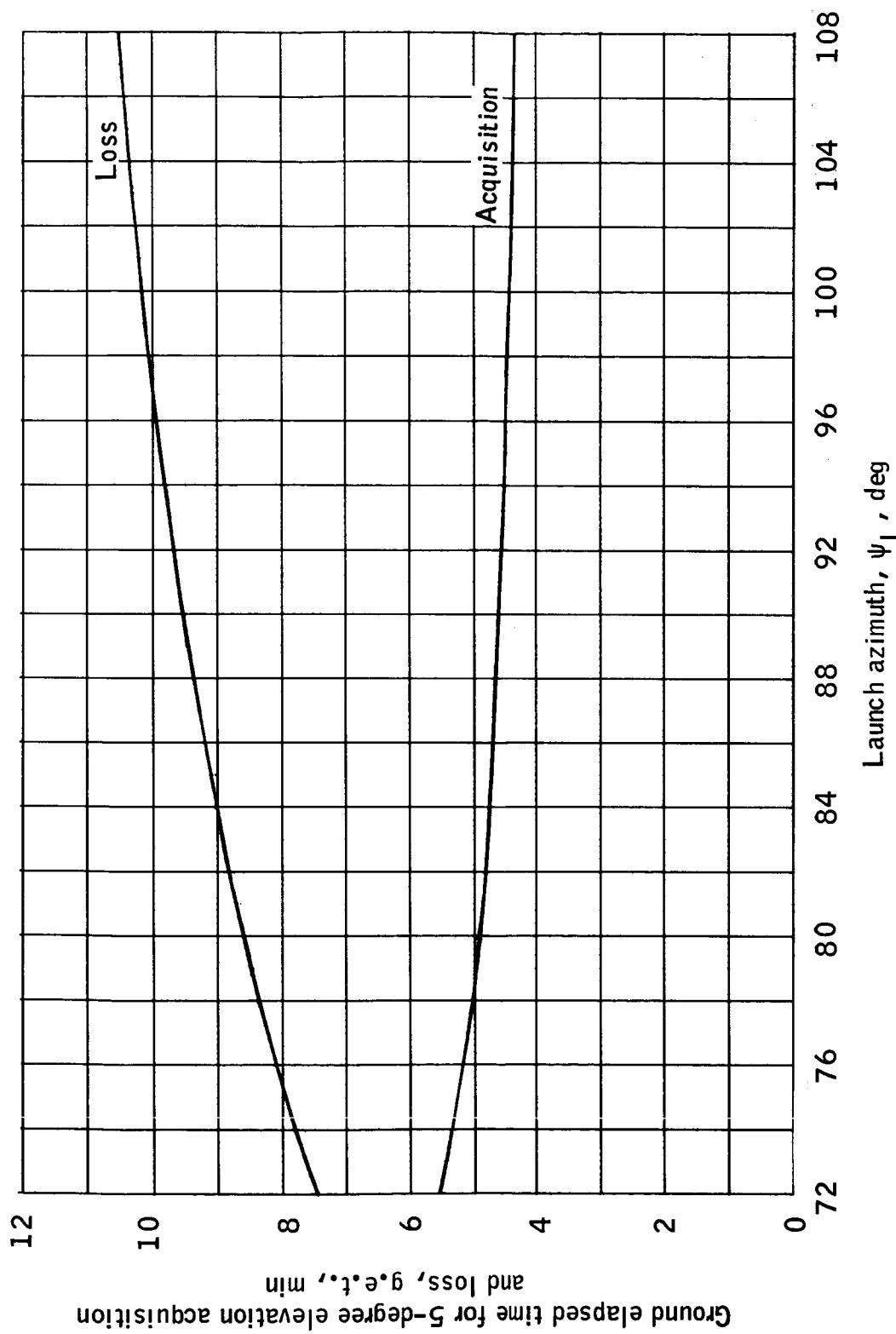
(b) Total tracking time above 5-degree elevation.

Figure 8.- Continued.



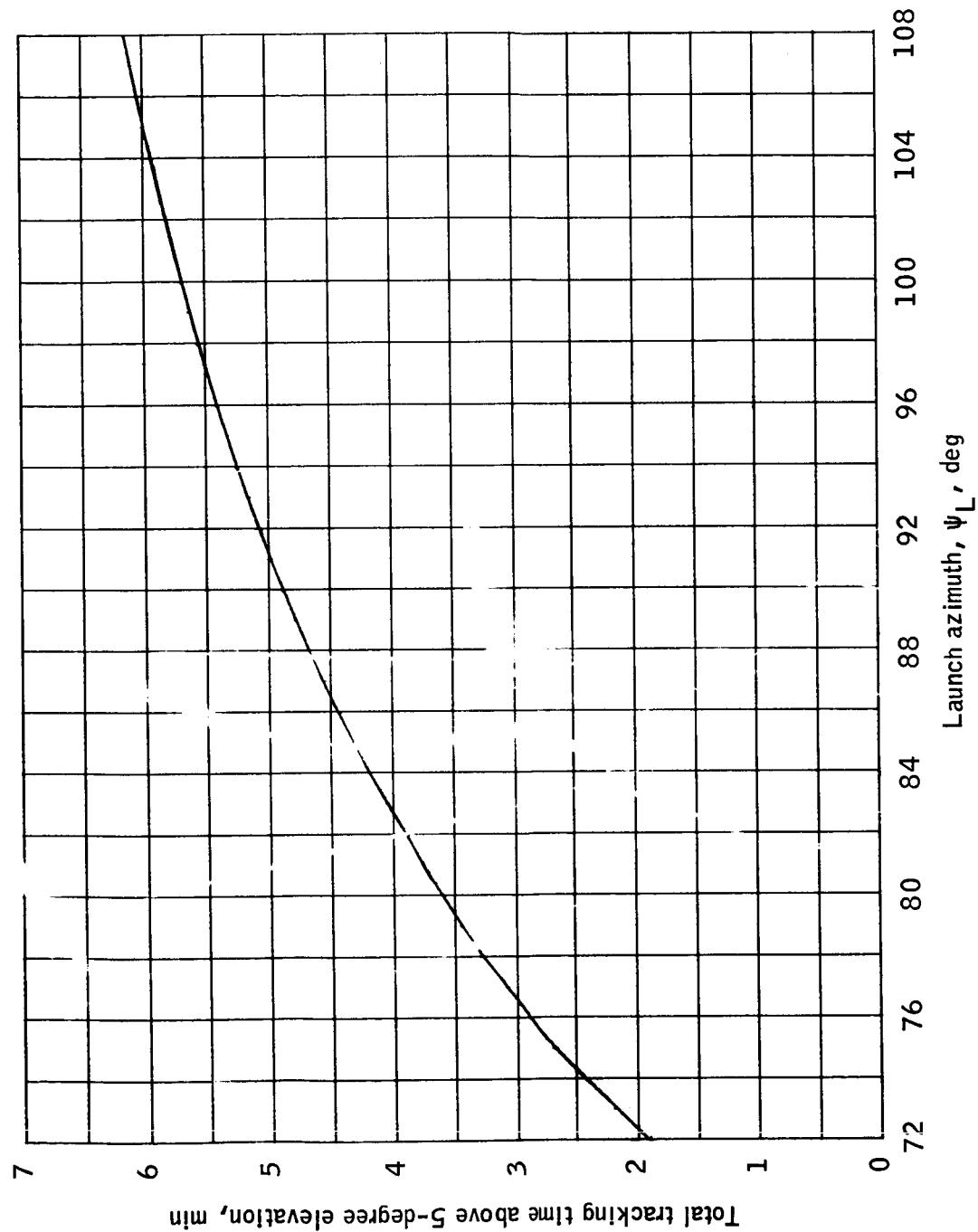
(c) Azimuth of acquisition for 5-degree elevation.

Figure 8.- Concluded.



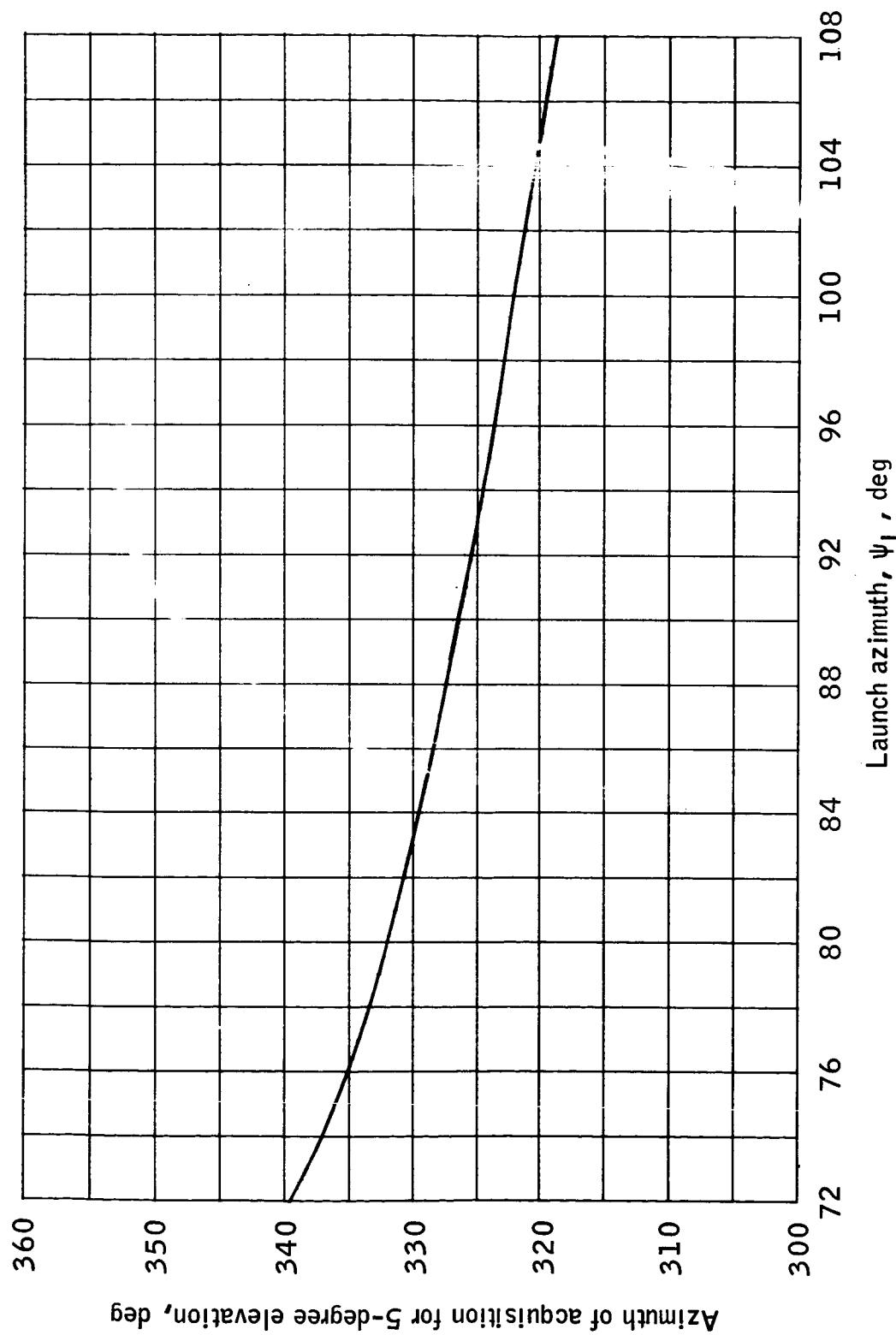
(a) Ground elapsed time for 5-degree acquisition and loss.

Figure 9. - Grand Turk C-band radar tracking information for the first 15 minutes after launch as a function of launch azimuth.



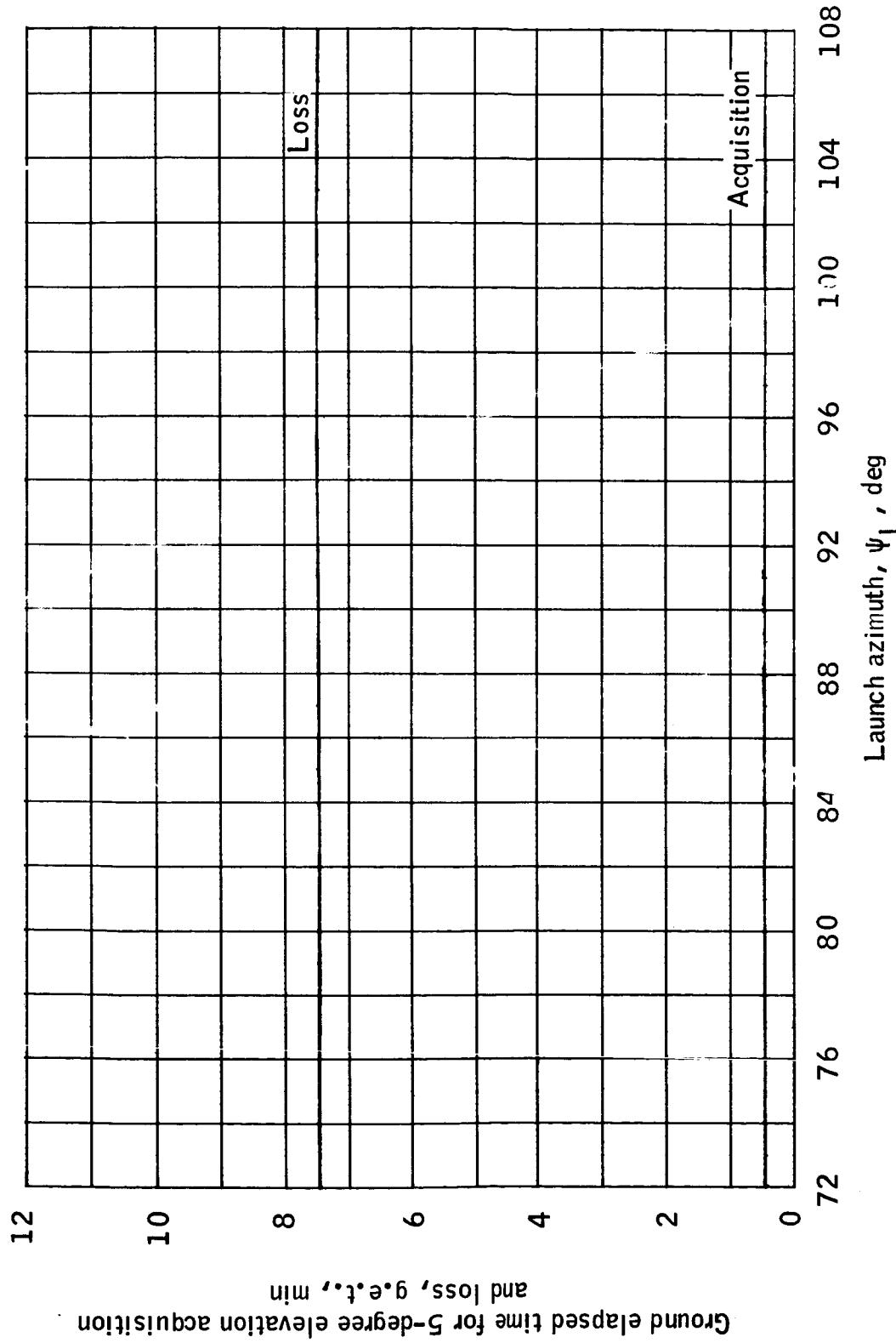
(b) Total tracking time above 5-degree elevation.

Figure 9.- Continued.



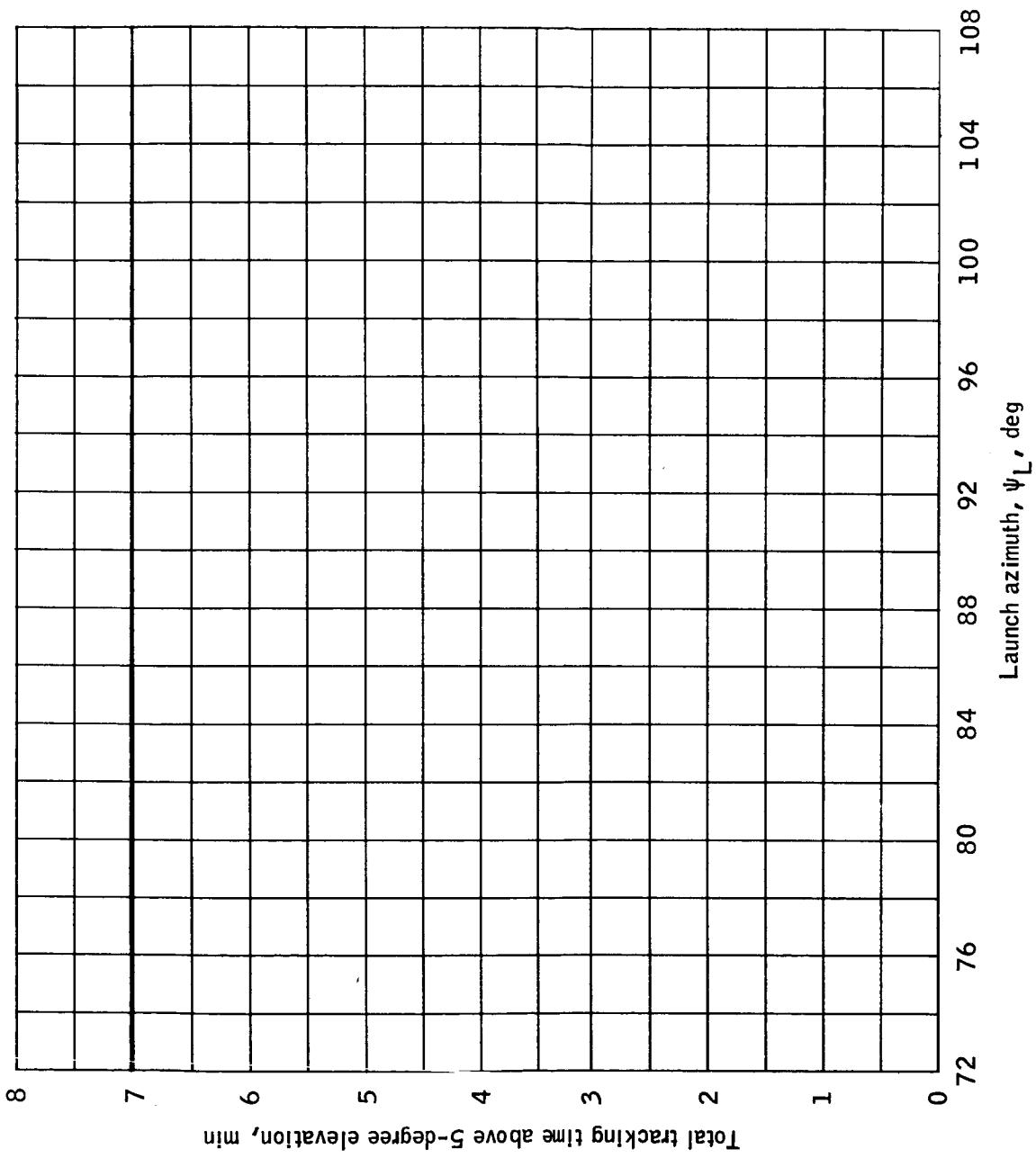
(c) Azimuth of acquisition for 5-degree elevation.

Figure 9.- Concluded.



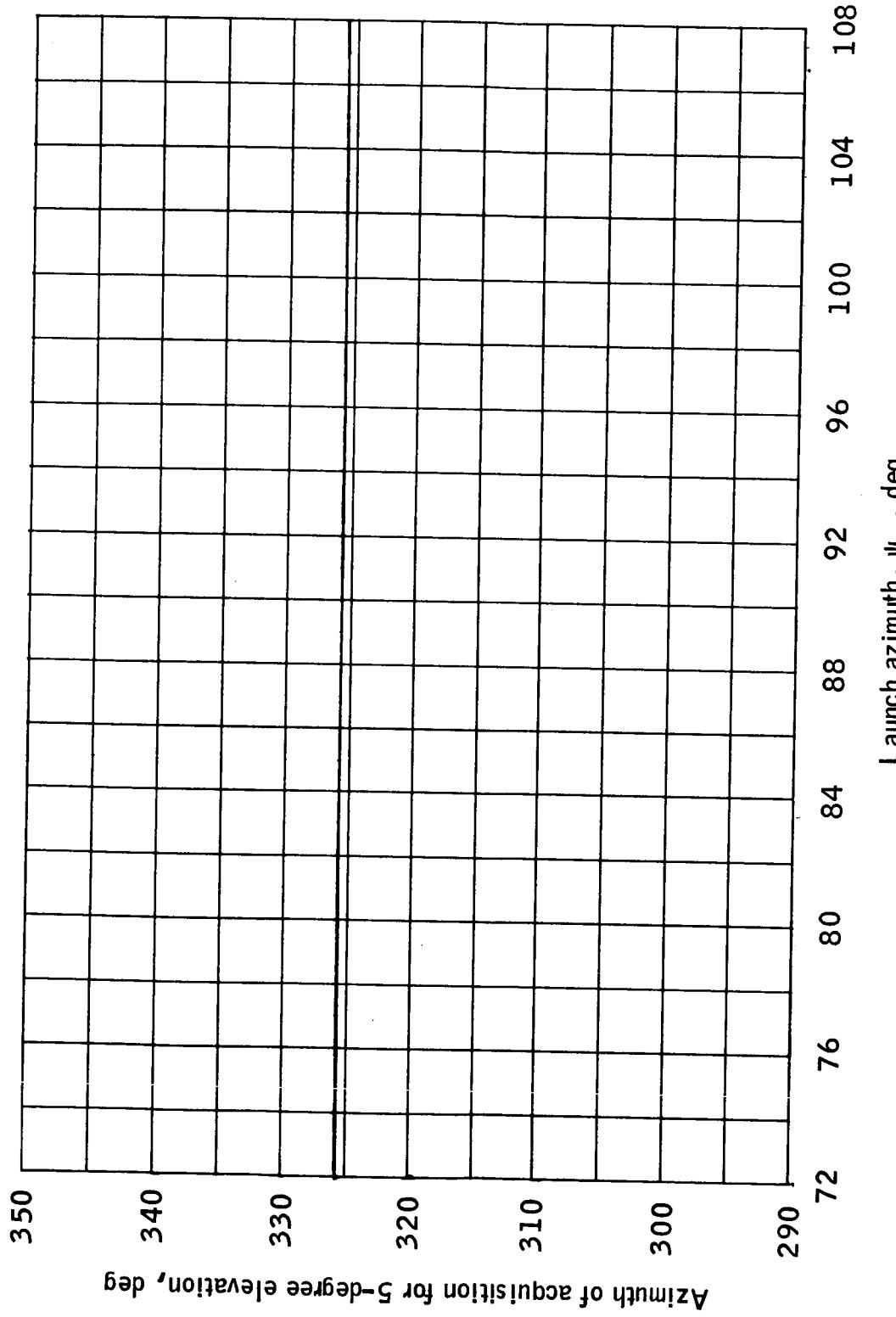
(a) Ground elapsed time for 5-degree acquisition and loss.

Figure 10.- Merritt Island USBS radar tracking information for the first 15 minutes after launch as a function of launch azimuth.



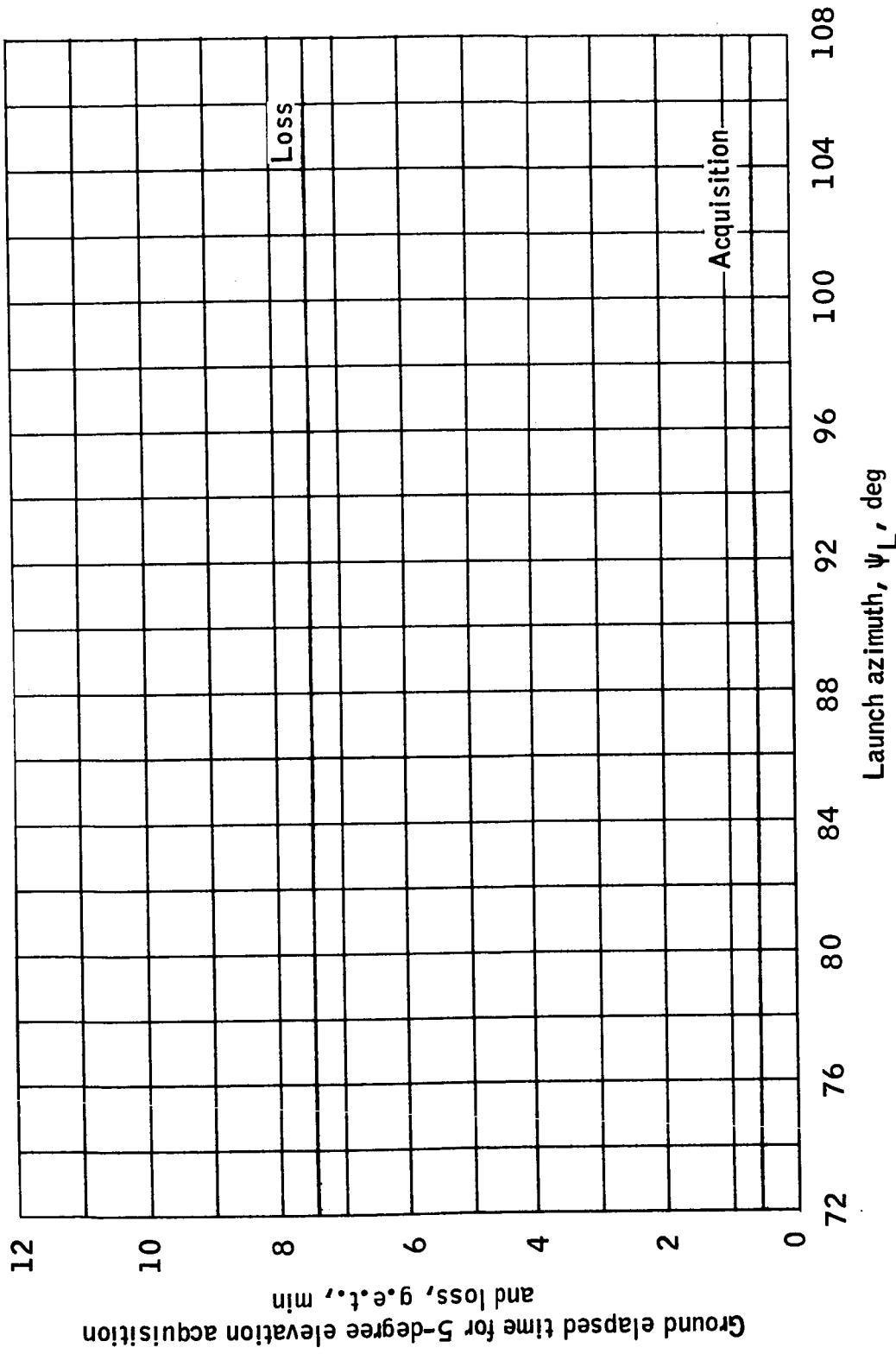
(b) Total tracking time above 5-degree elevation.

Figure 10.- Continued.



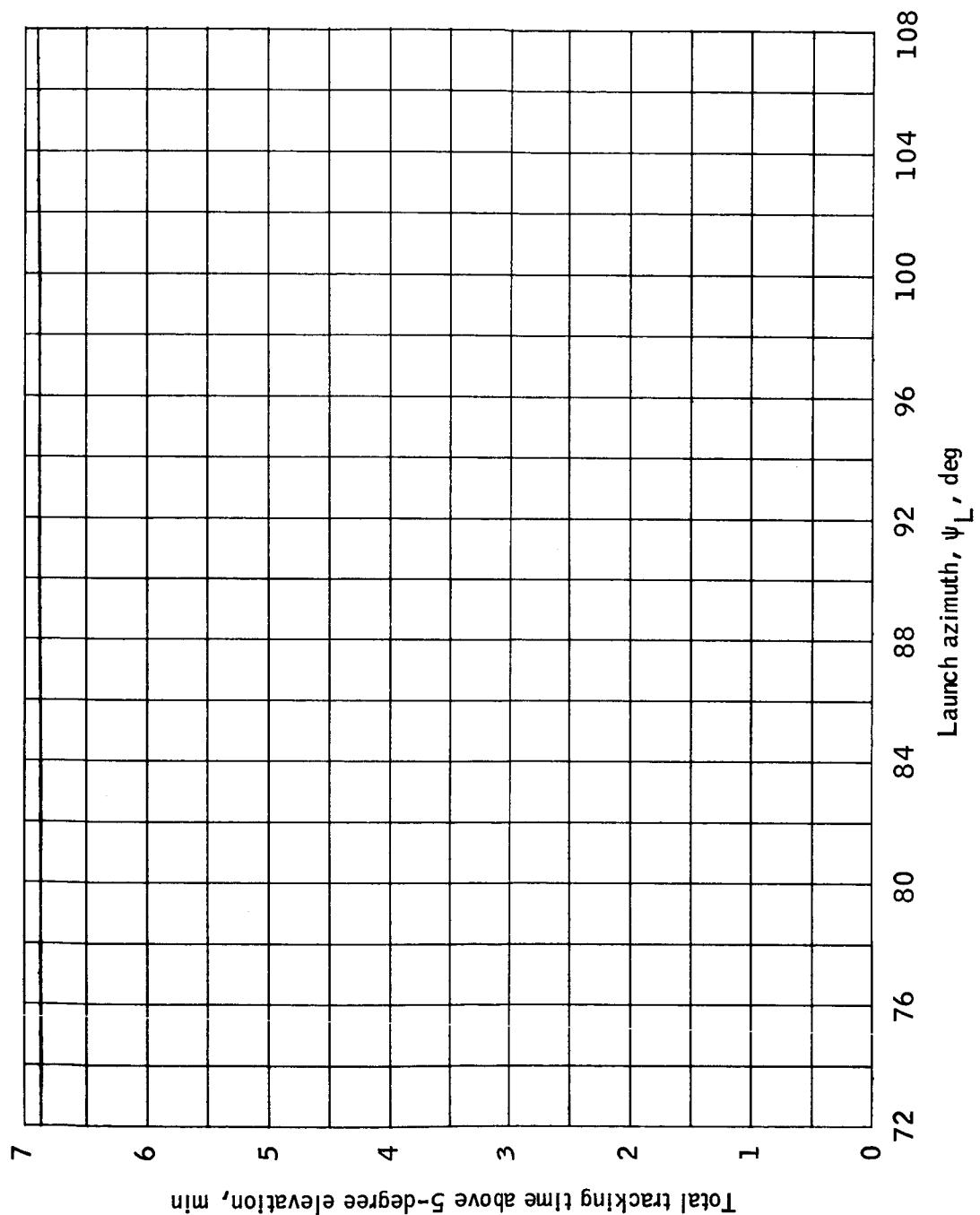
(c) Azimuth of acquisition for 5-degree elevation.

Figure 10.- Concluded.



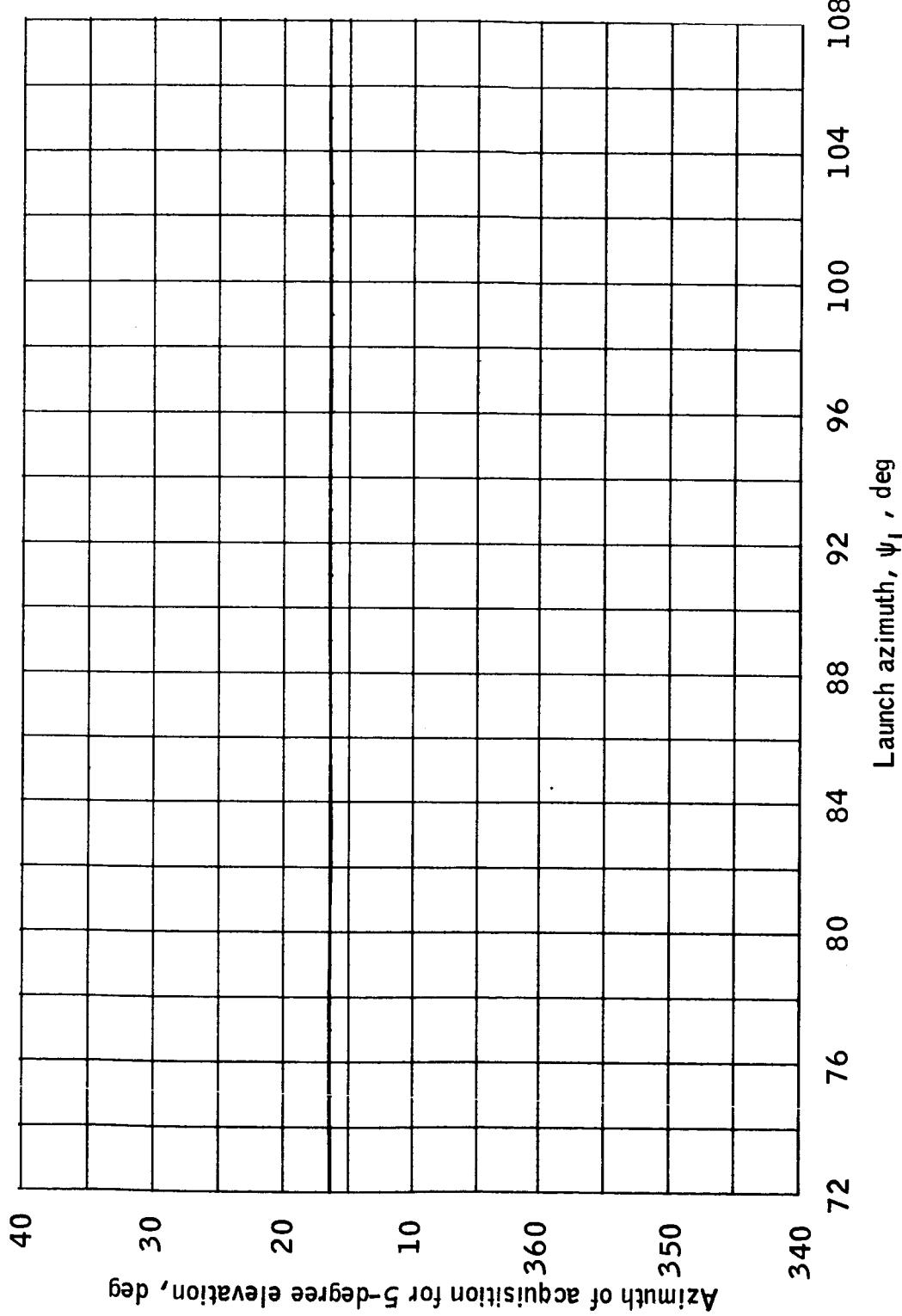
(a) Ground elapsed time for 5-degree acquisition and loss.

Figure 11.- Merritt Island C-band radar tracking information for the first 15 minutes after launch as a function of launch azimuth.



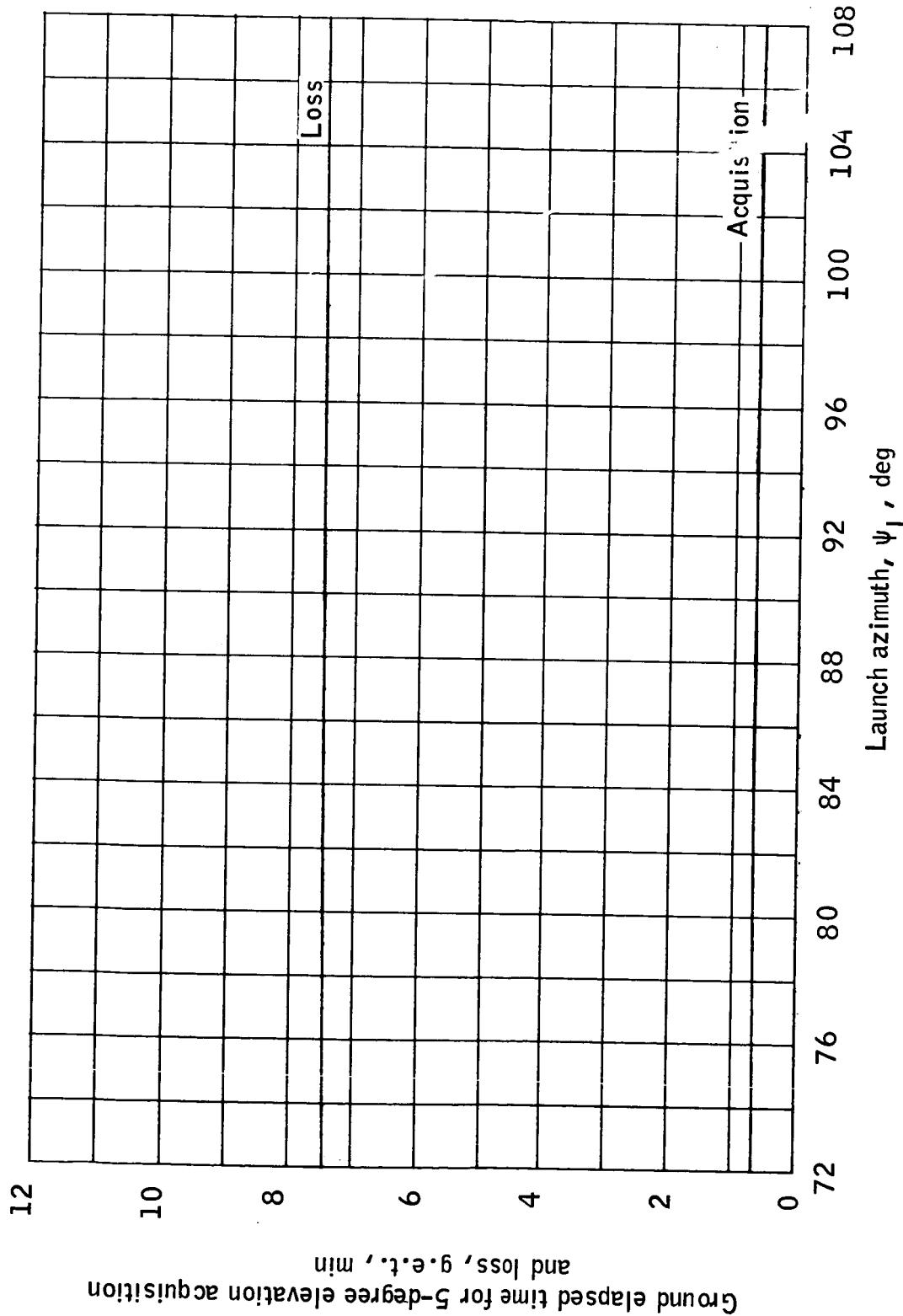
(b) Total tracking time above 5-degree elevation.

Figure 11.- Continued.



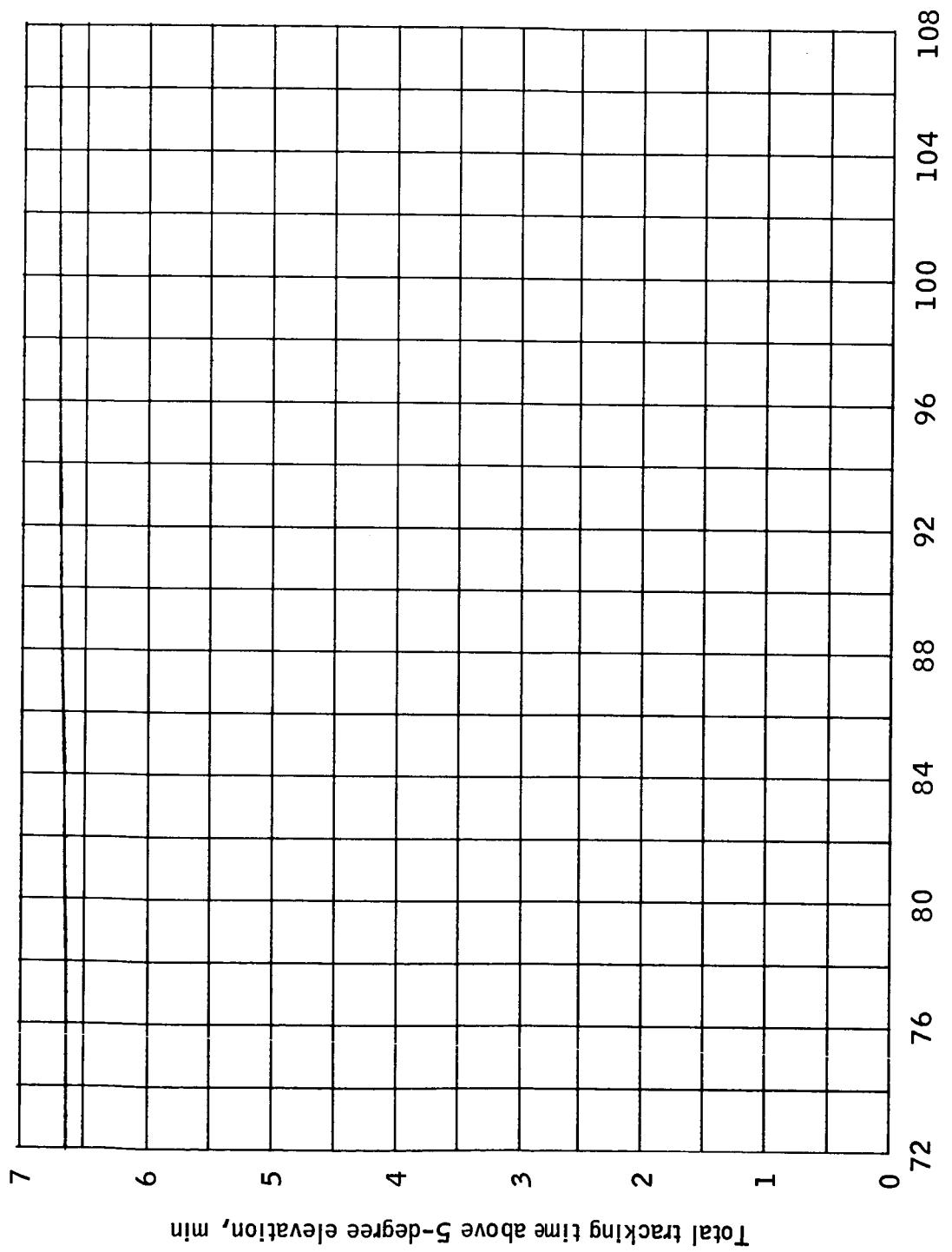
(c) Azimuth of acquisition for 5-degree elevation.

Figure 11.- Concluded.



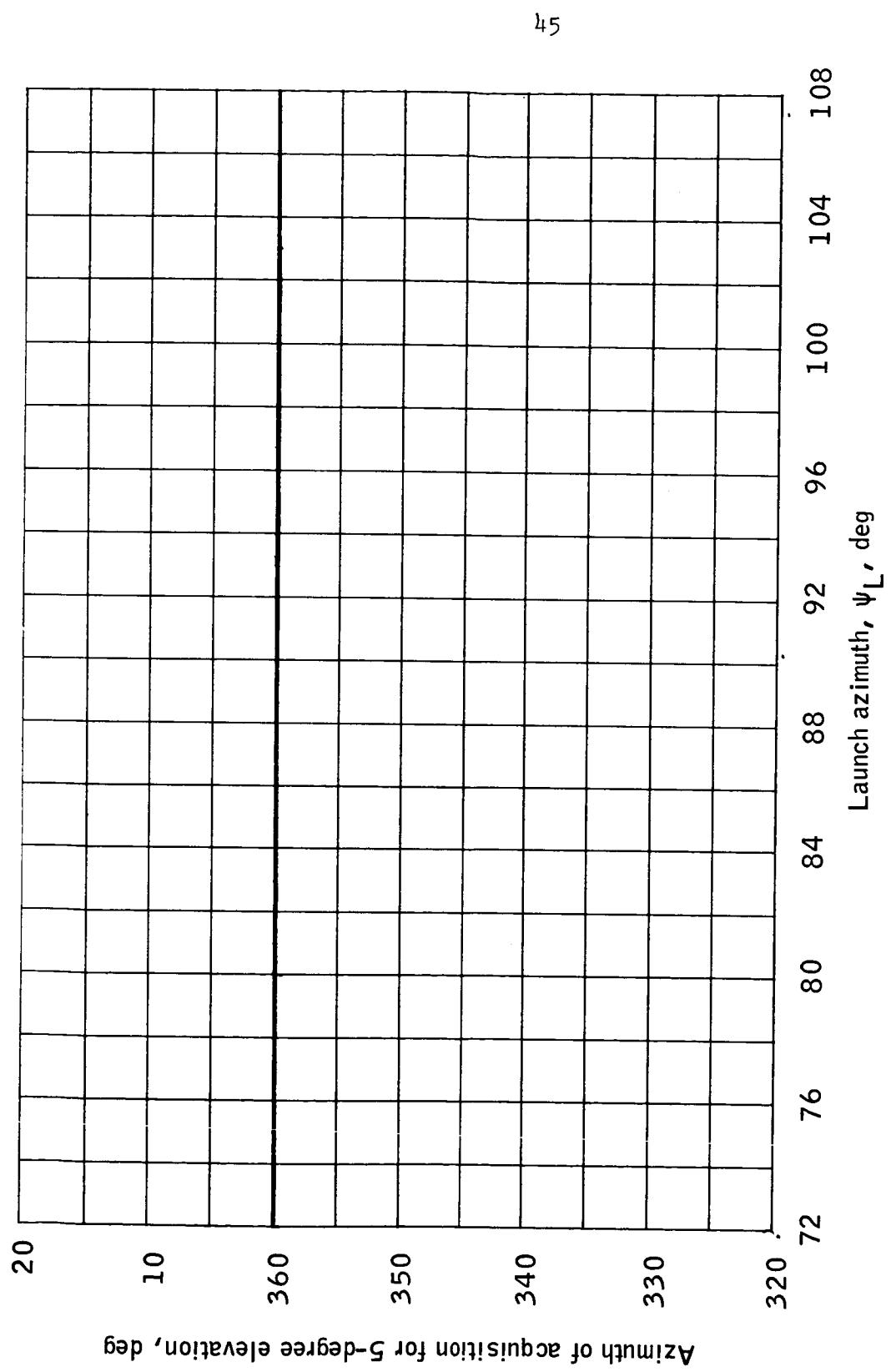
(a) Ground elapsed time for 5-degree acquisition and loss.

Figure 12.- Patrick Air Force Base C-band radar tracking information for the first 15 minutes after launch as a function of launch azimuth.



(b) Total tracking time above 5-degree elevation.

Figure 12.- Continued.



(c) Azimuth of acquisition for 5-degree elevation.

Figure 12.- Concluded.

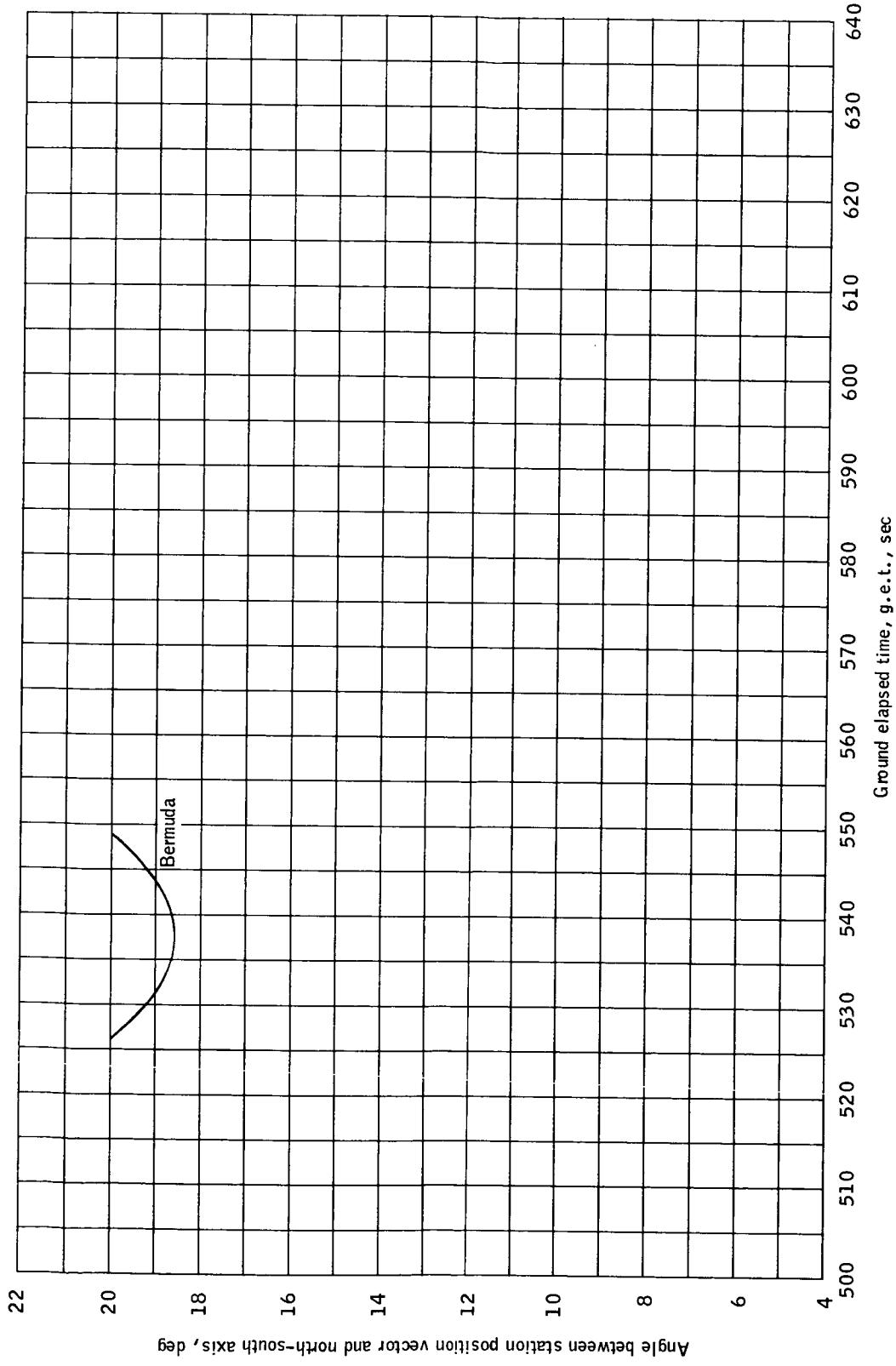
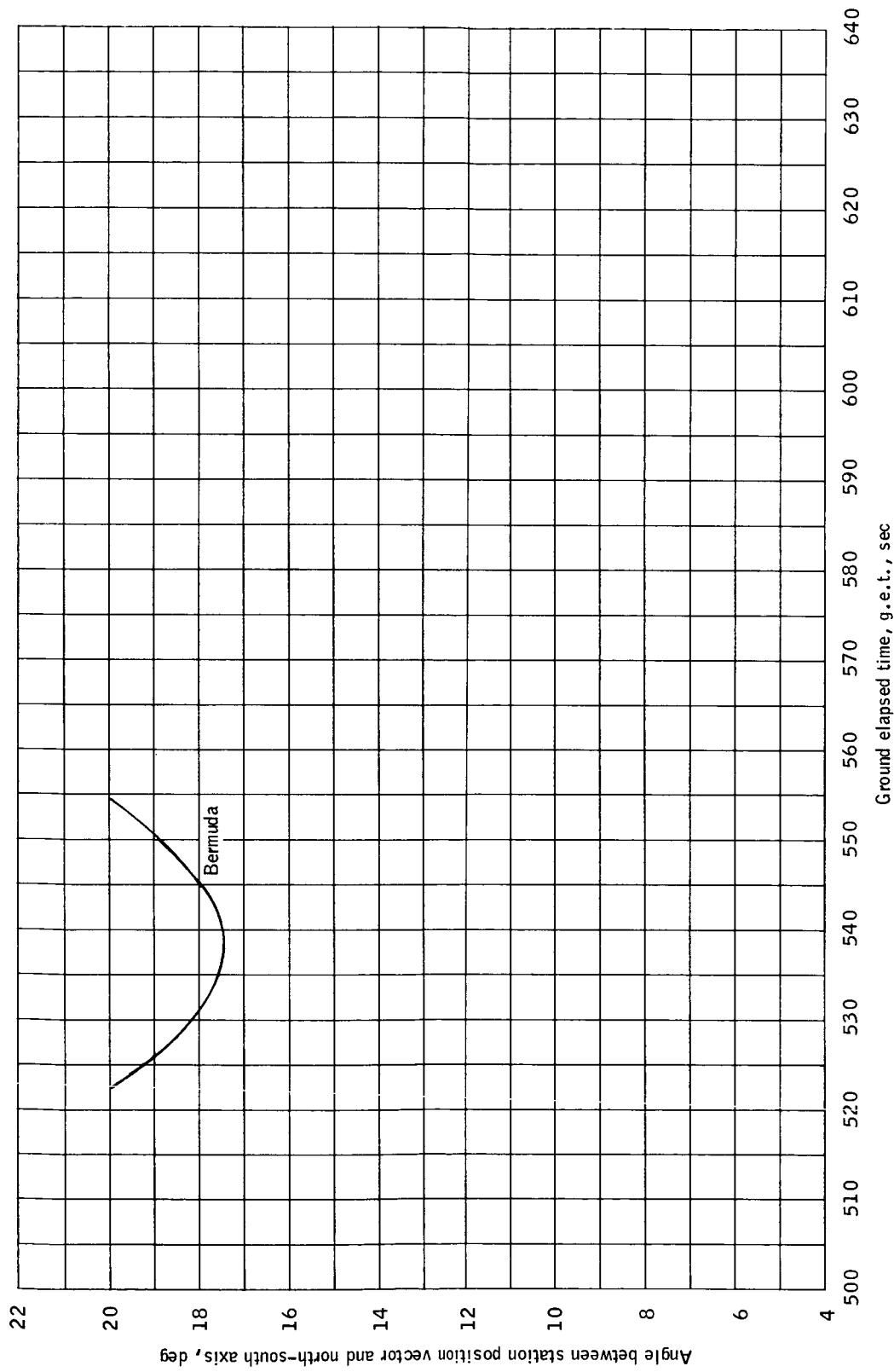
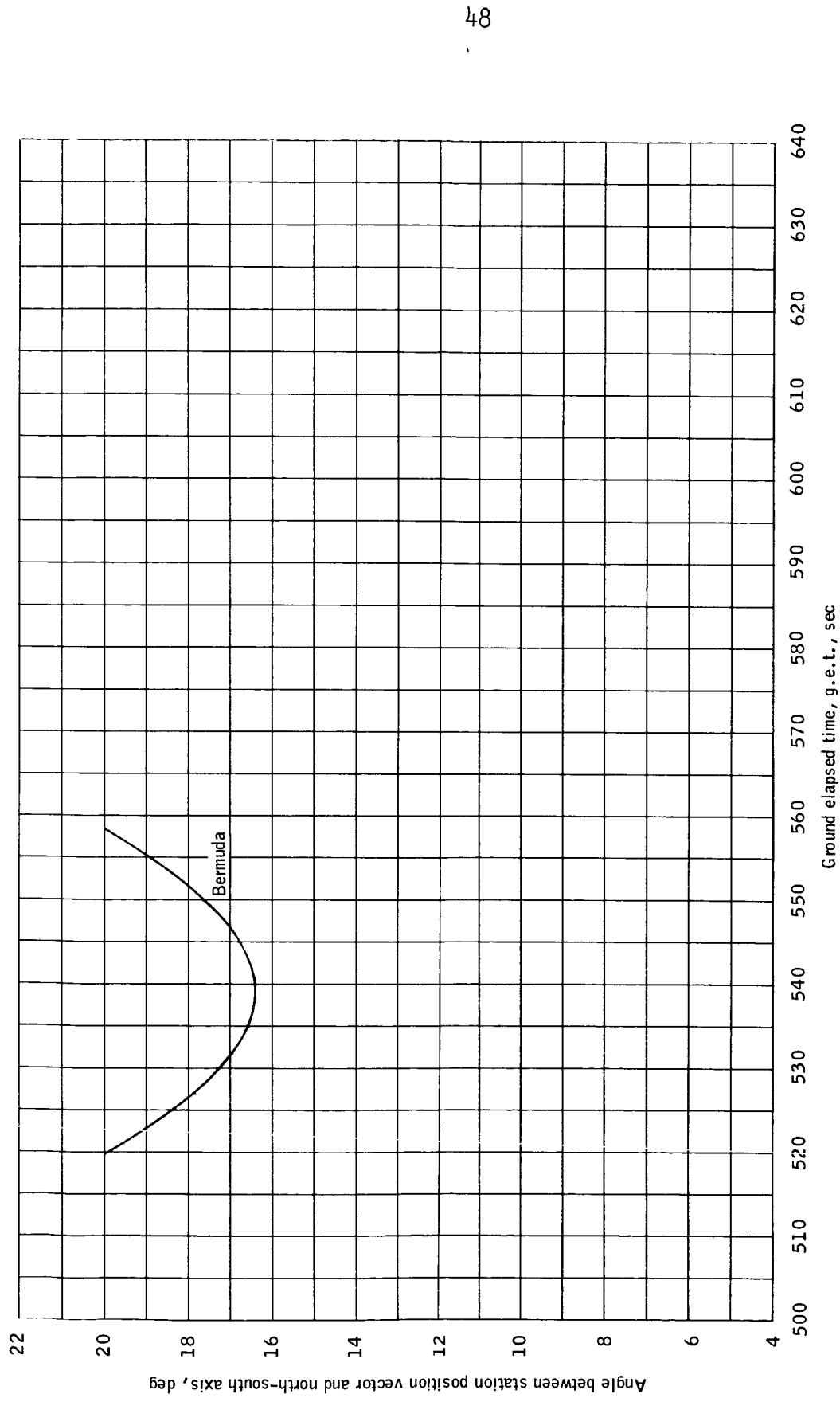


Figure 13.- Time history of the angle between station position vector and north-south axis versus ground elapsed time for various azimuths.  
(a) 88-degree launch azimuth.



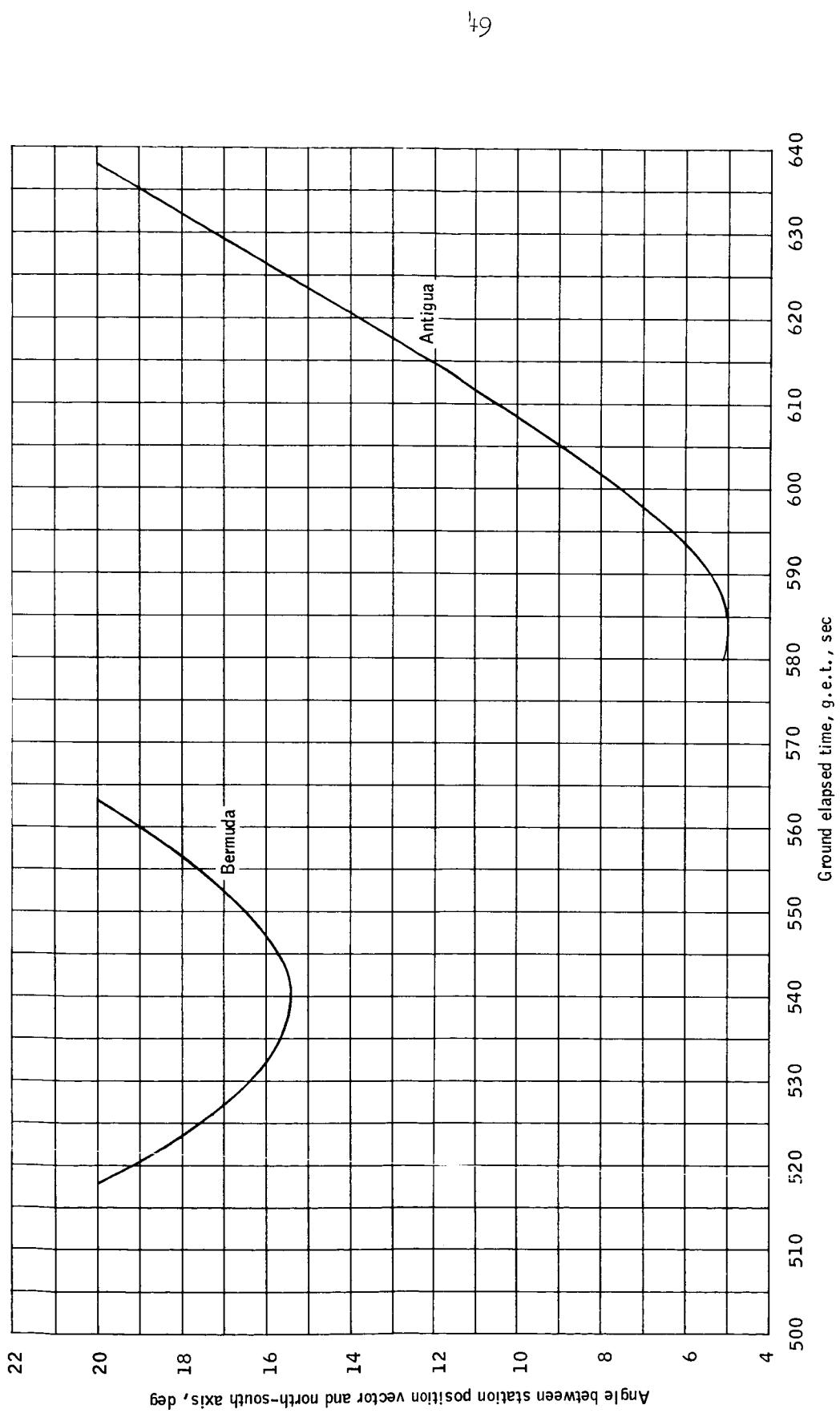
(b) 89-degree launch azimuth.

Figure 13.-Continued.



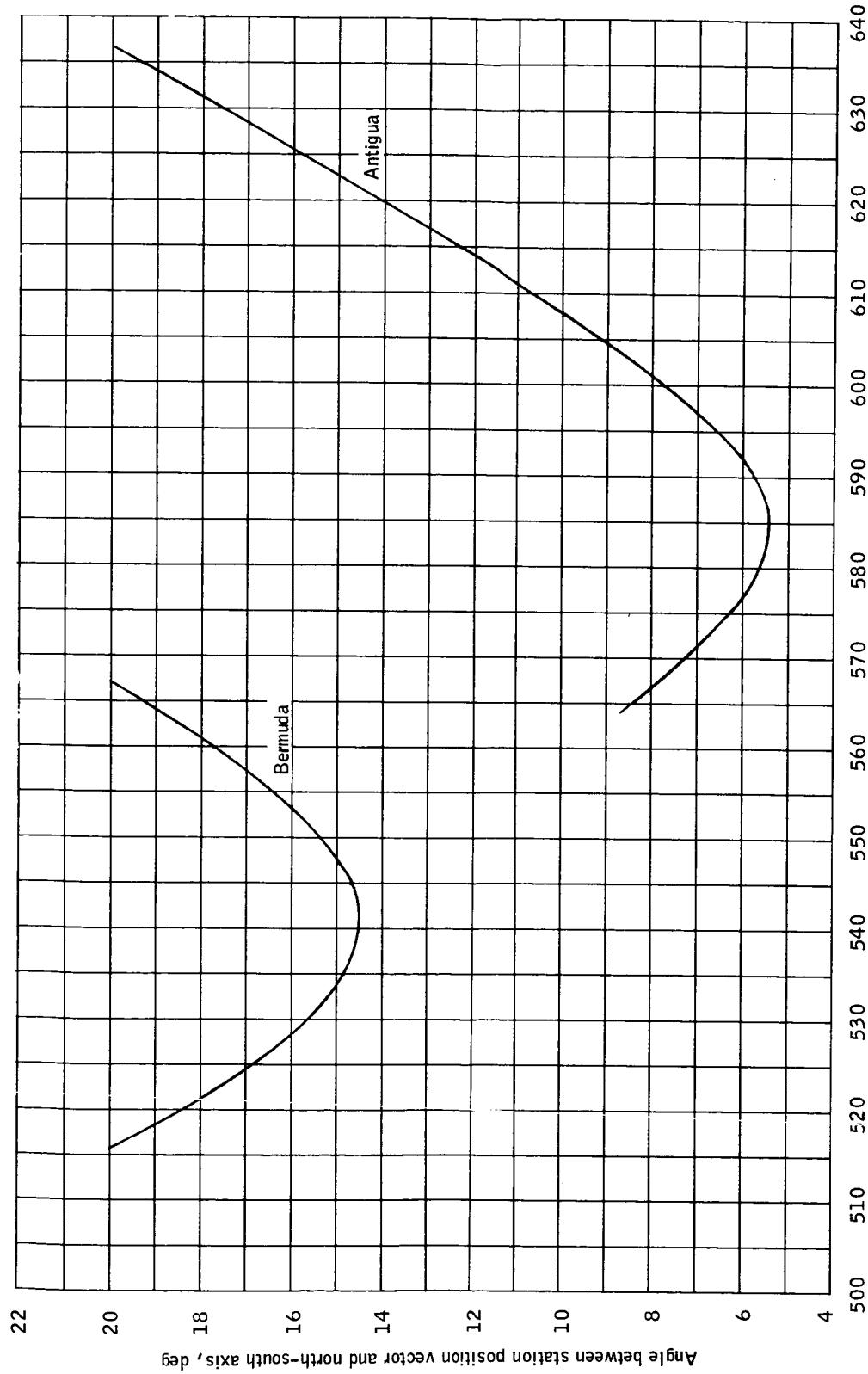
(c) 90-degree launch azimuth.

Figure 13.- Continued.



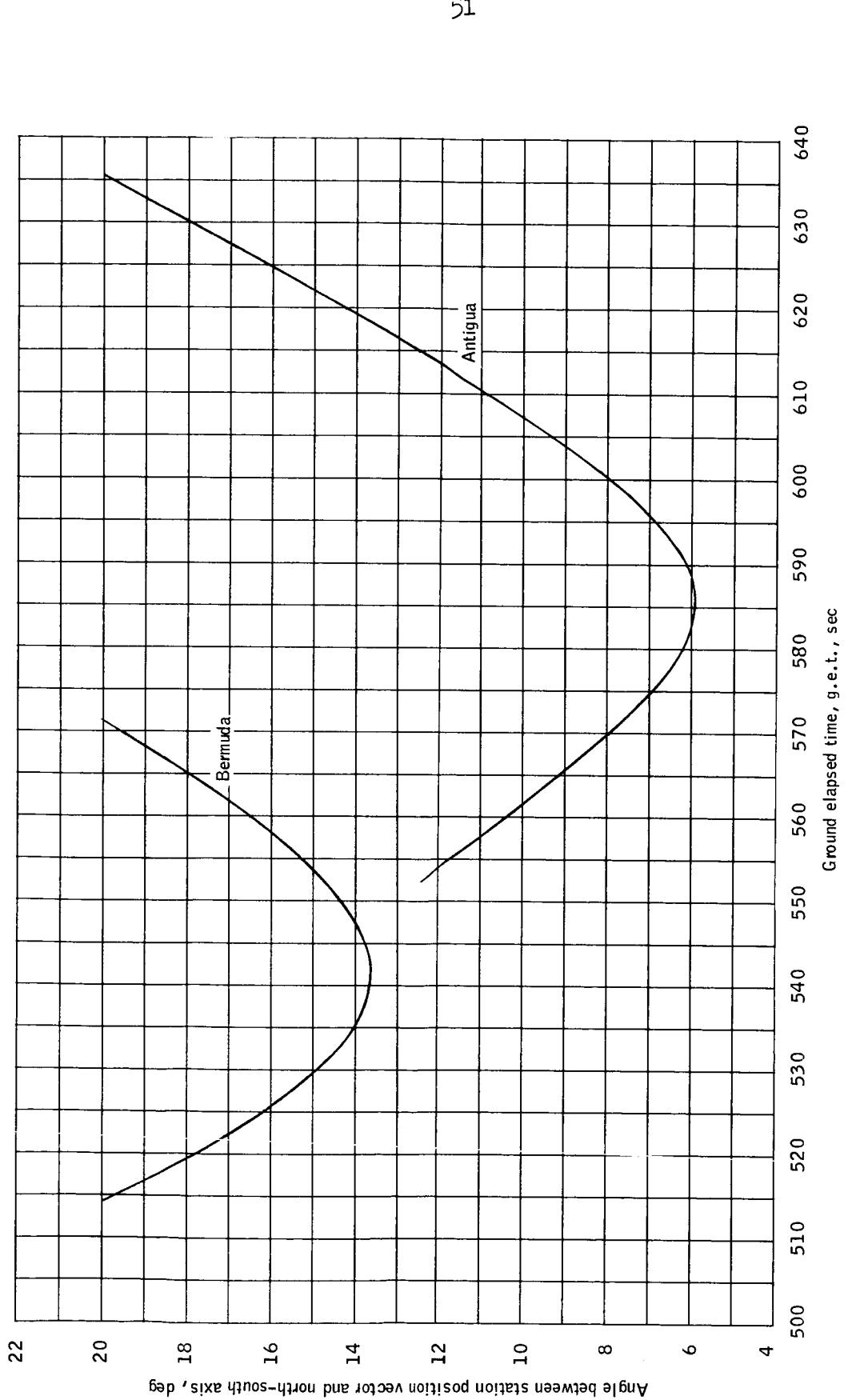
(d) 91-degree launch azimuth.

Figure 13.- Continued.



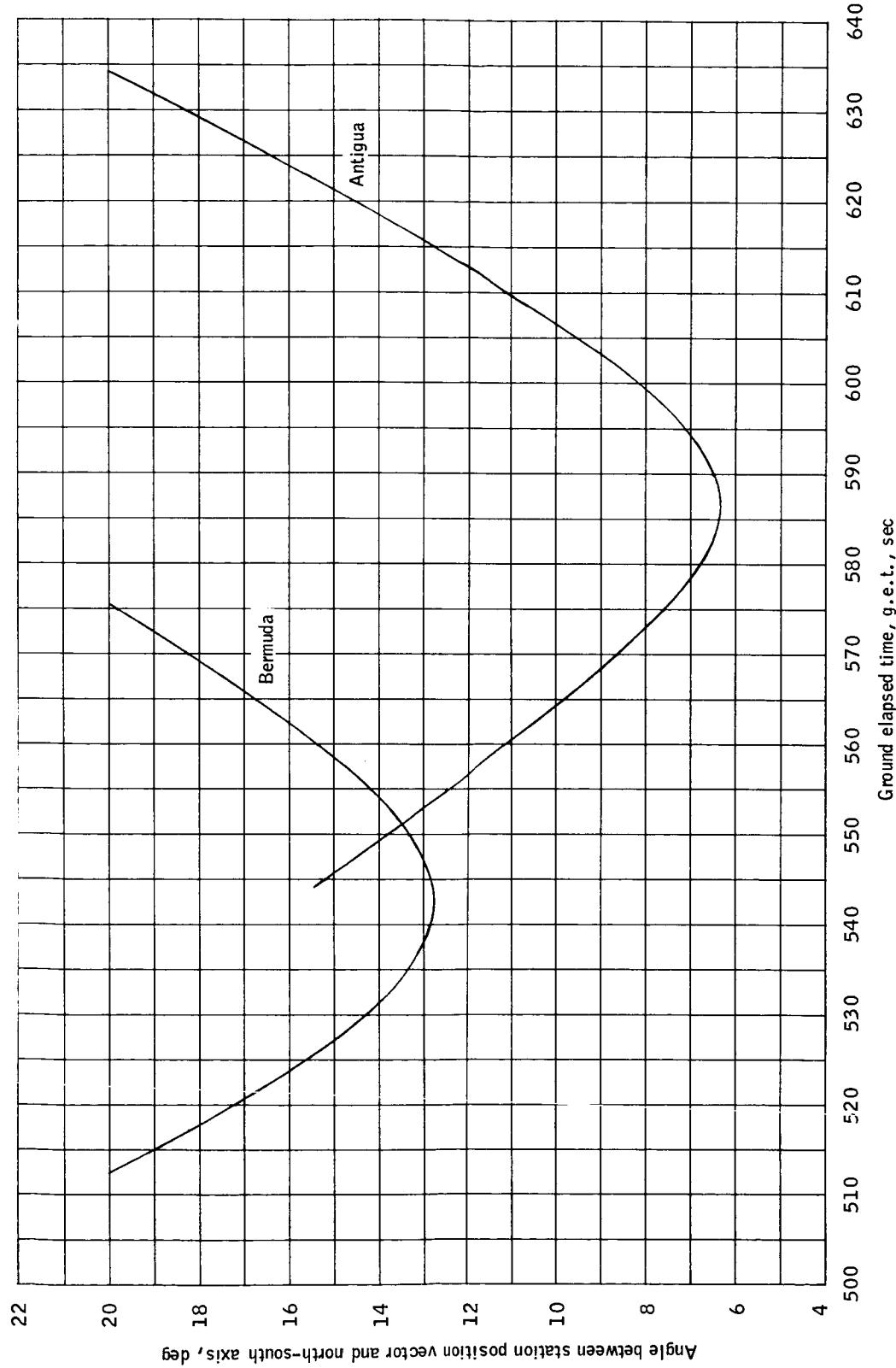
(e) 92-degree launch azimuth.

Figure 13.- Continued.



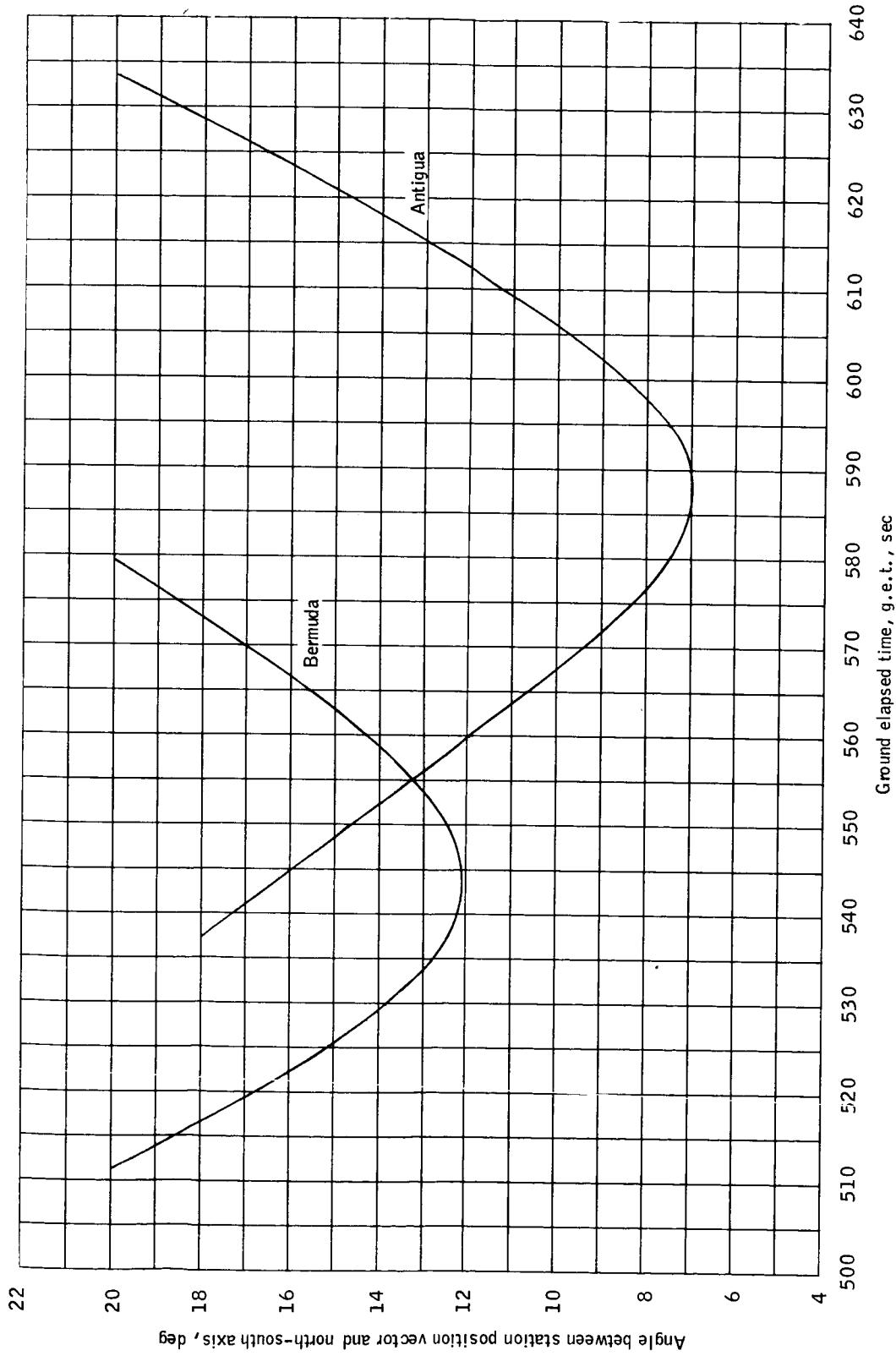
(f) 93-degree launch azimuth.

Figure 13.-Continued.



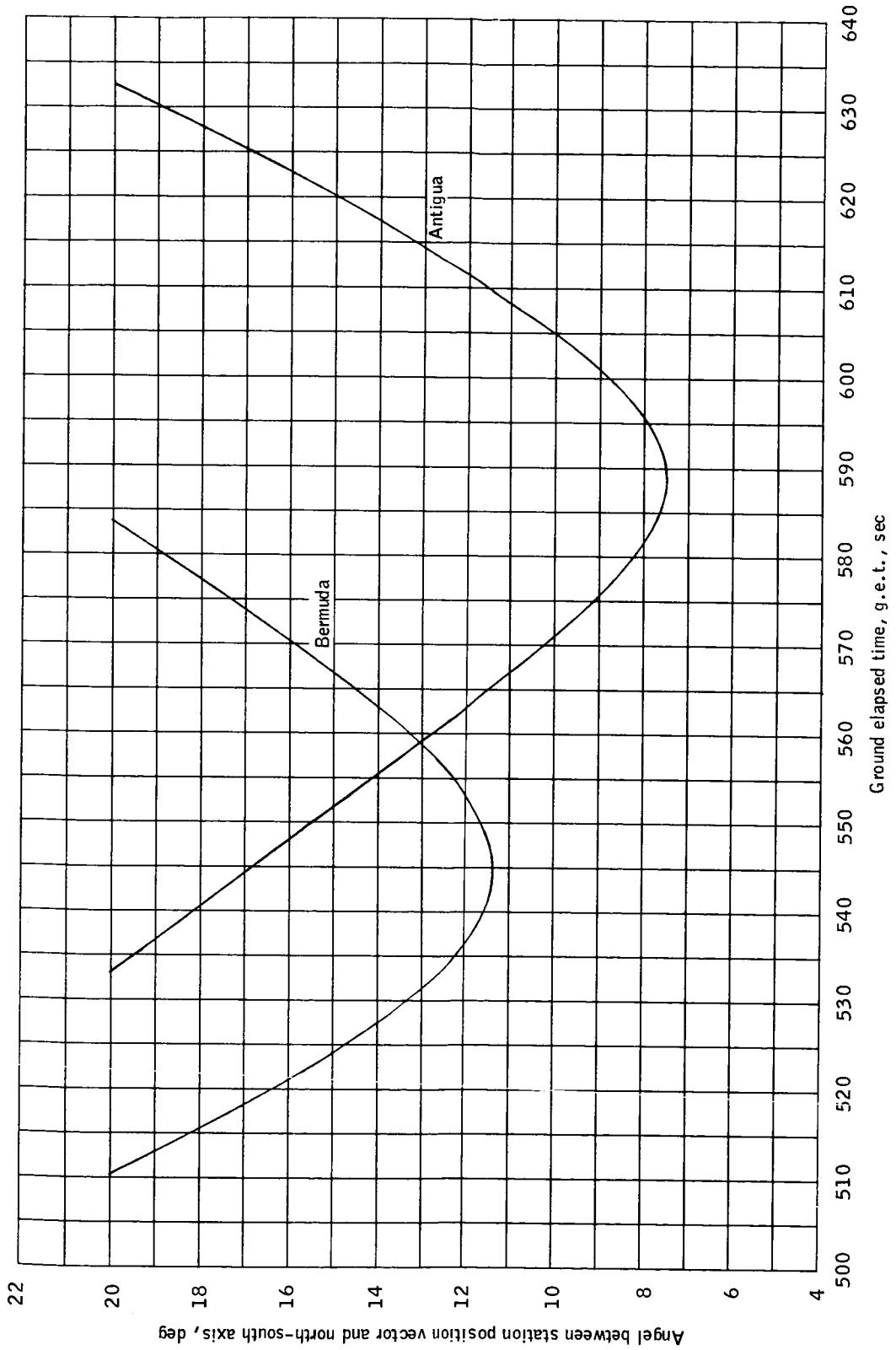
(g) 94-degree launch azimuth.

Figure 13.-Continued.



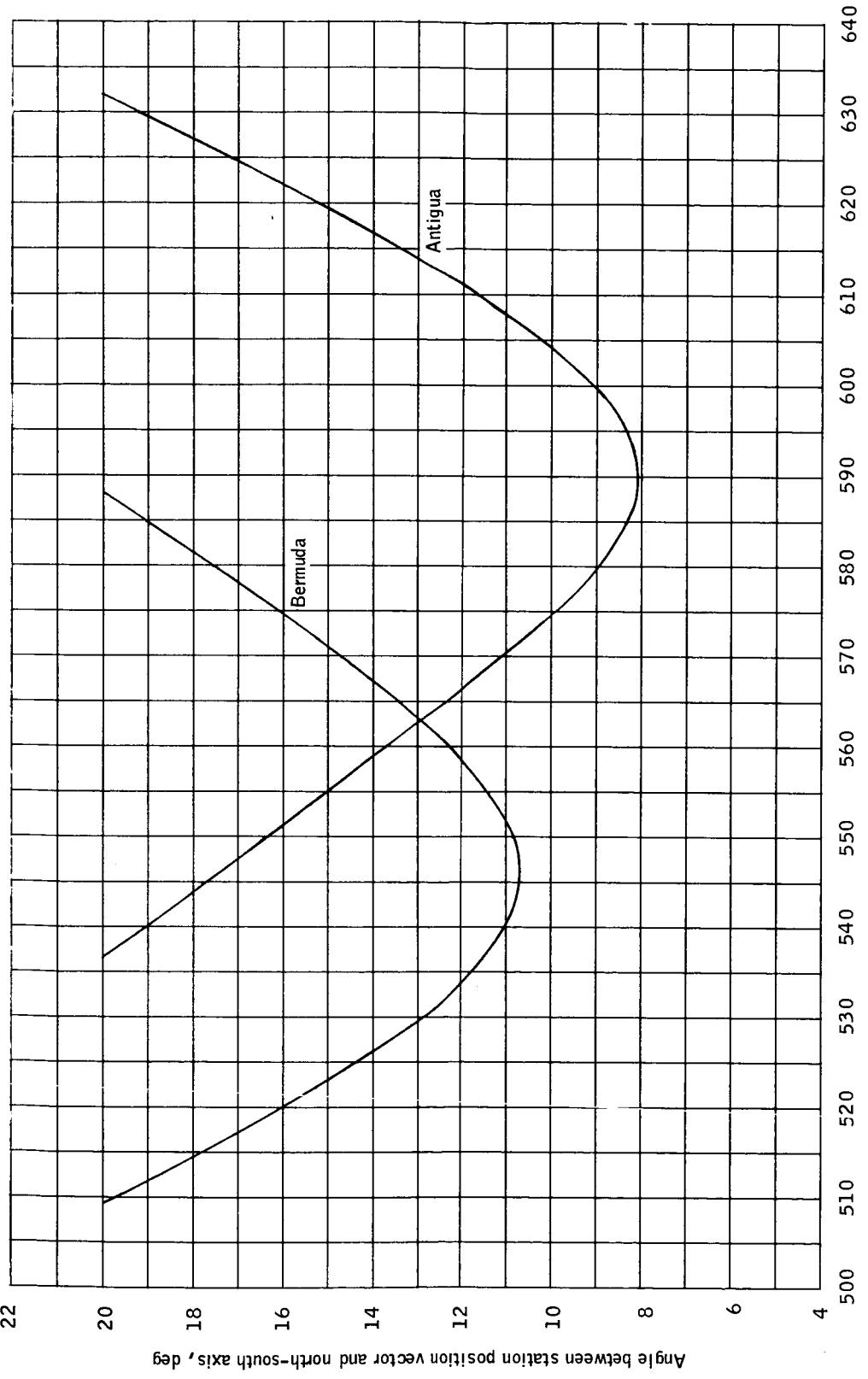
(h) 95-degree launch azimuth.

Figure 13.- Continued.



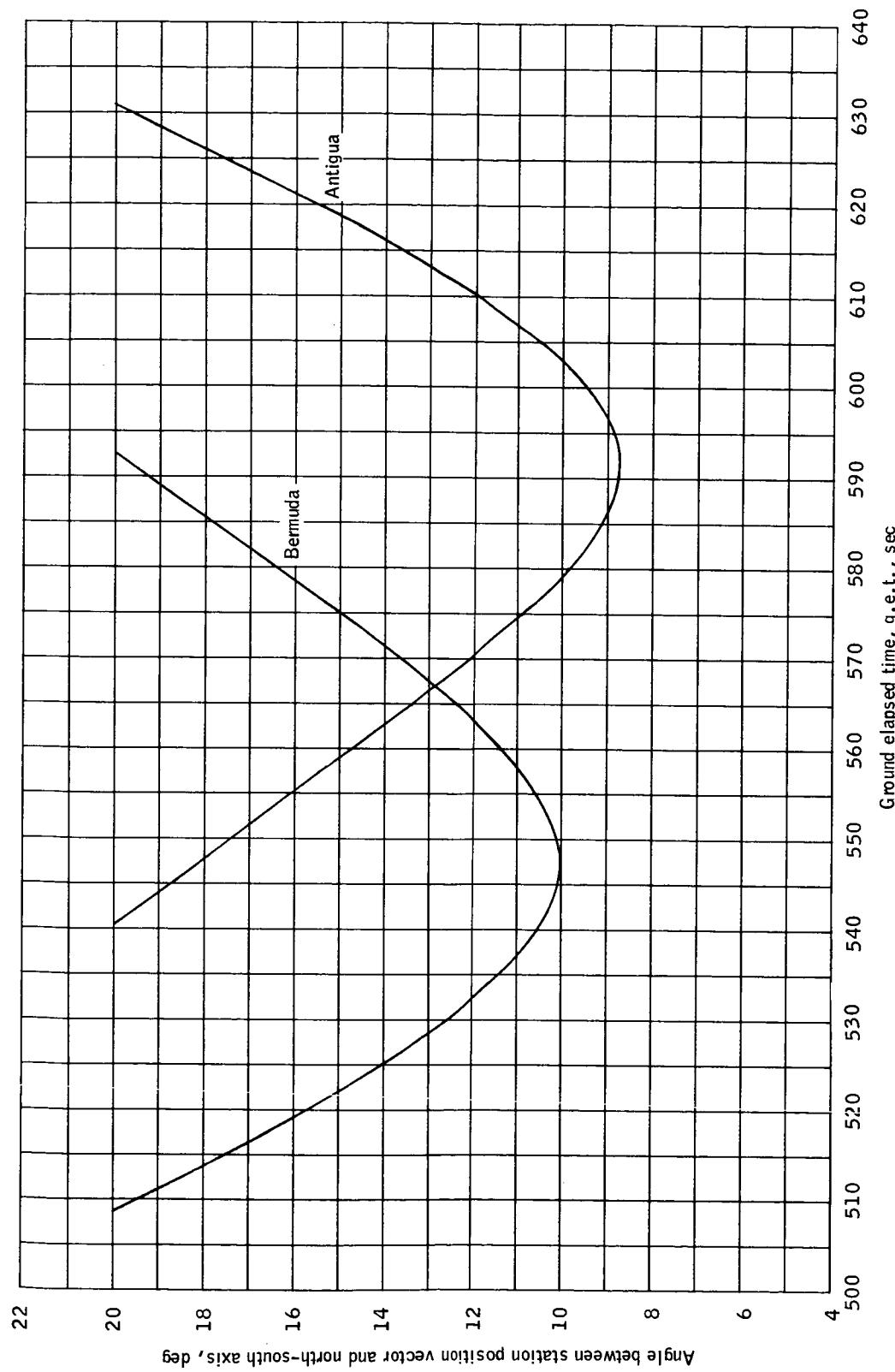
(i) 96-degree launch azimuth.

Figure 13.-Continued.



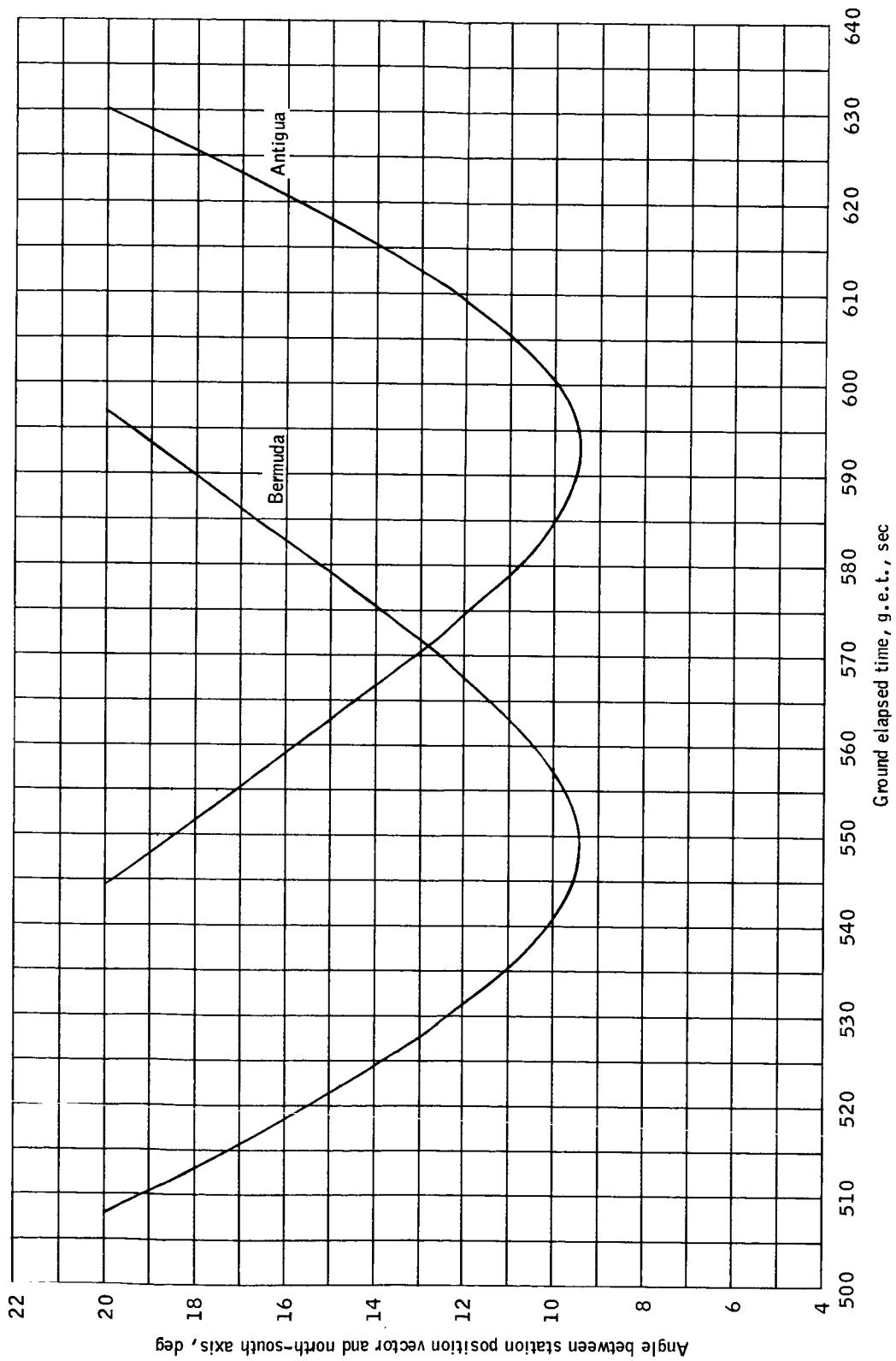
(j) 97-degree launch azimuth.

Figure 13.-Continued.



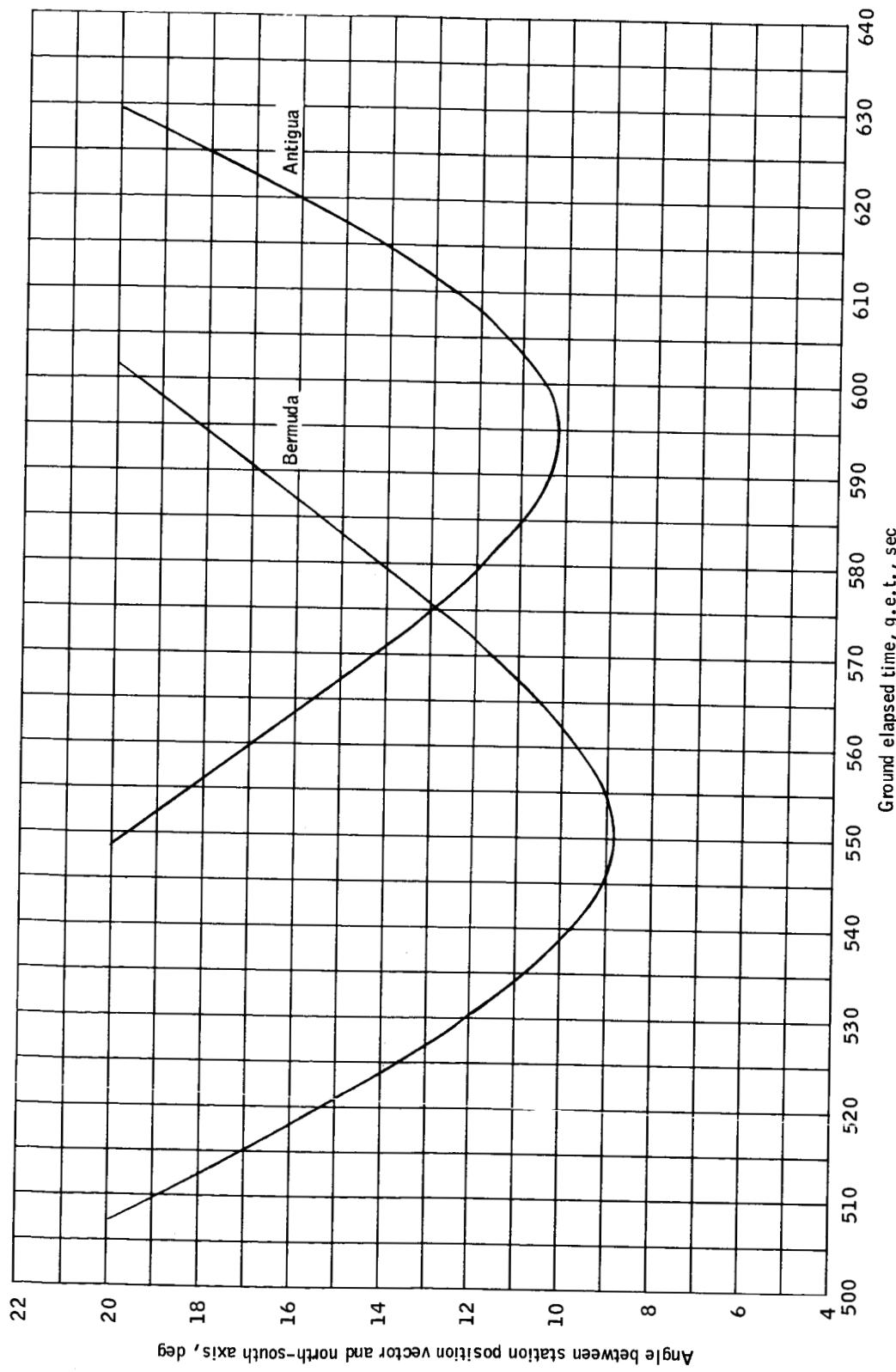
(k) 98-degree launch azimuth.

Figure 13.- Continued.



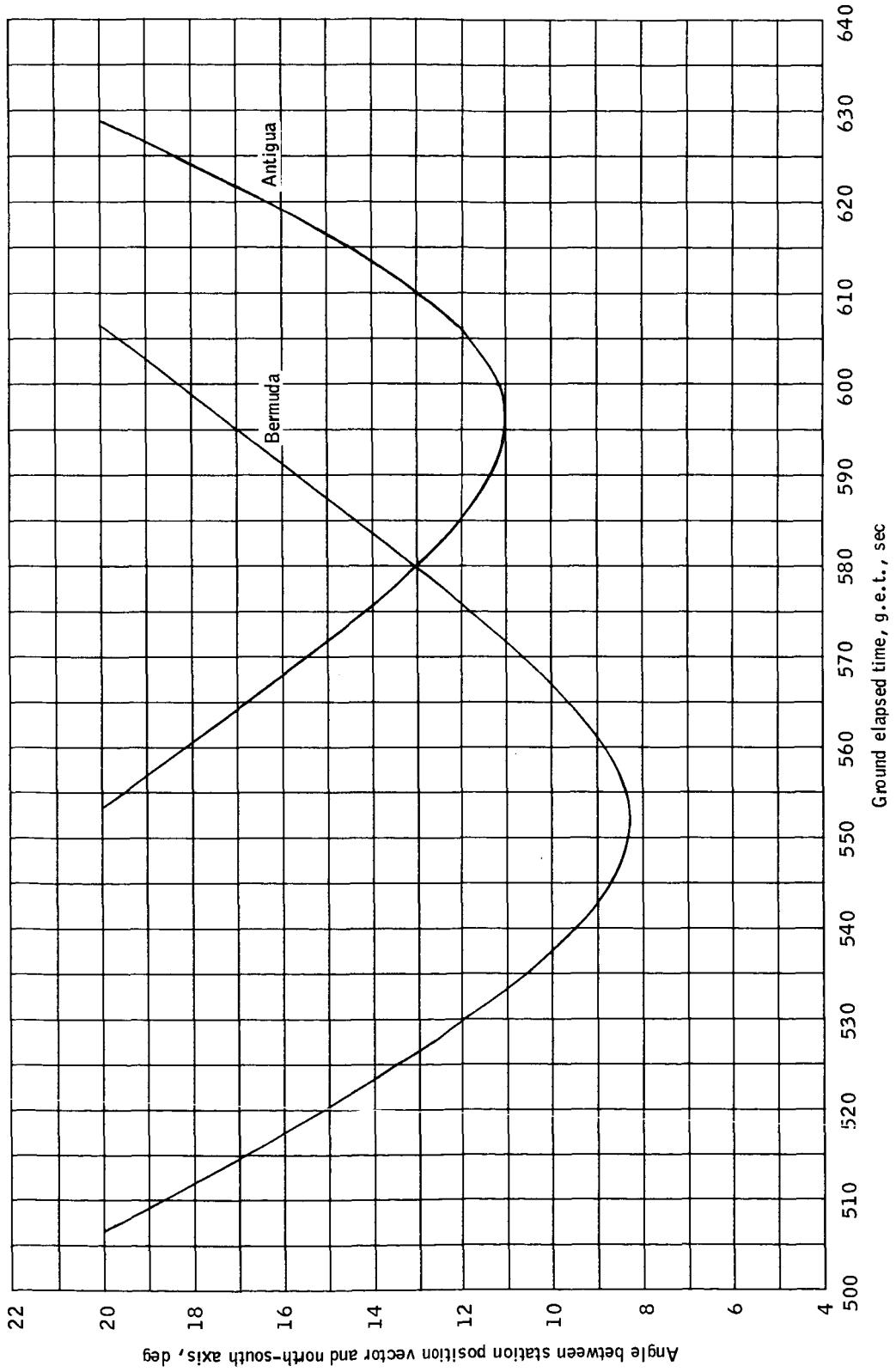
(I) 99-degree launch azimuth.

Figure 13.- Continued.



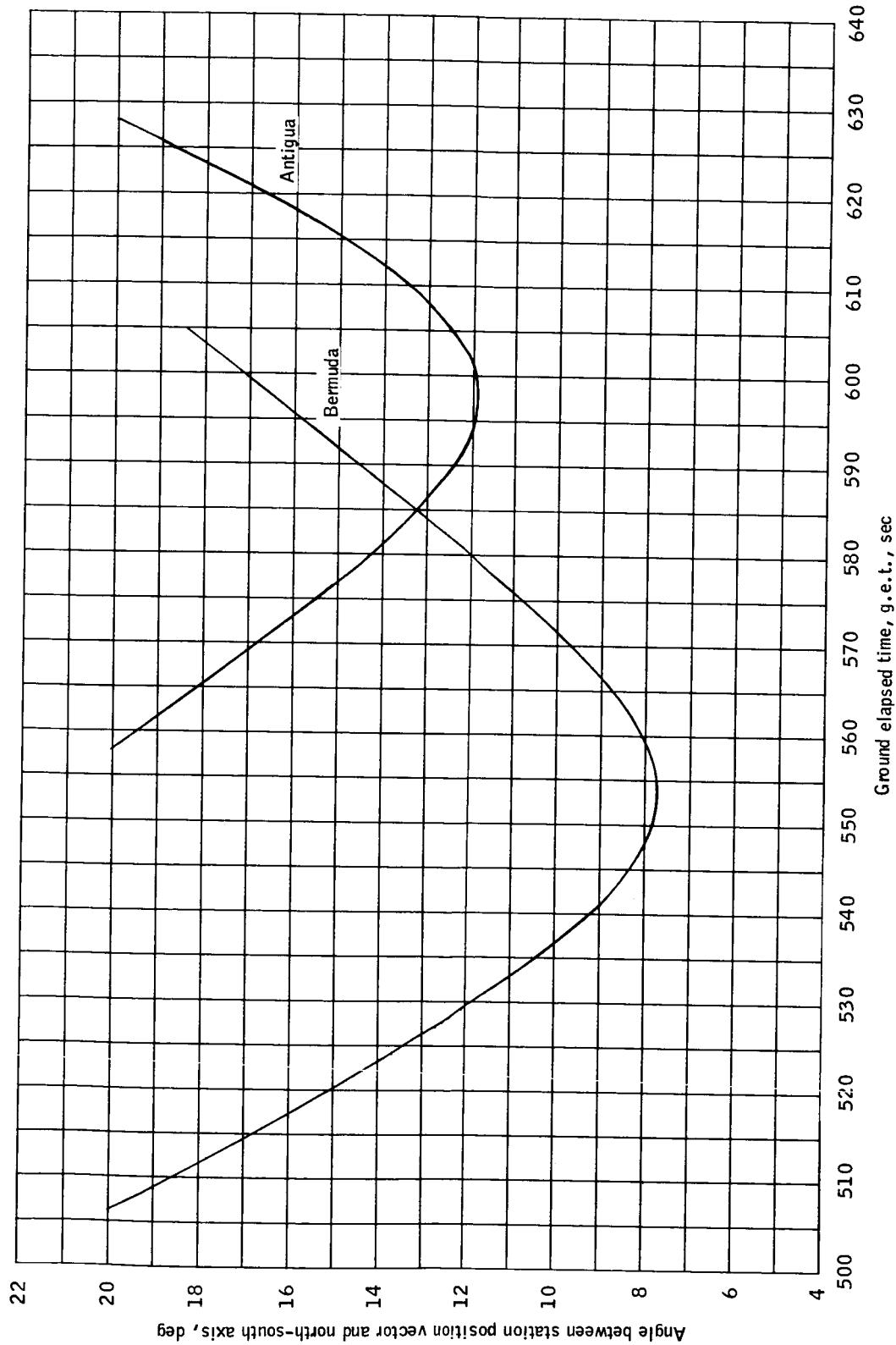
(m) 100-degree launch azimuth.

Figure 13.- Continued.



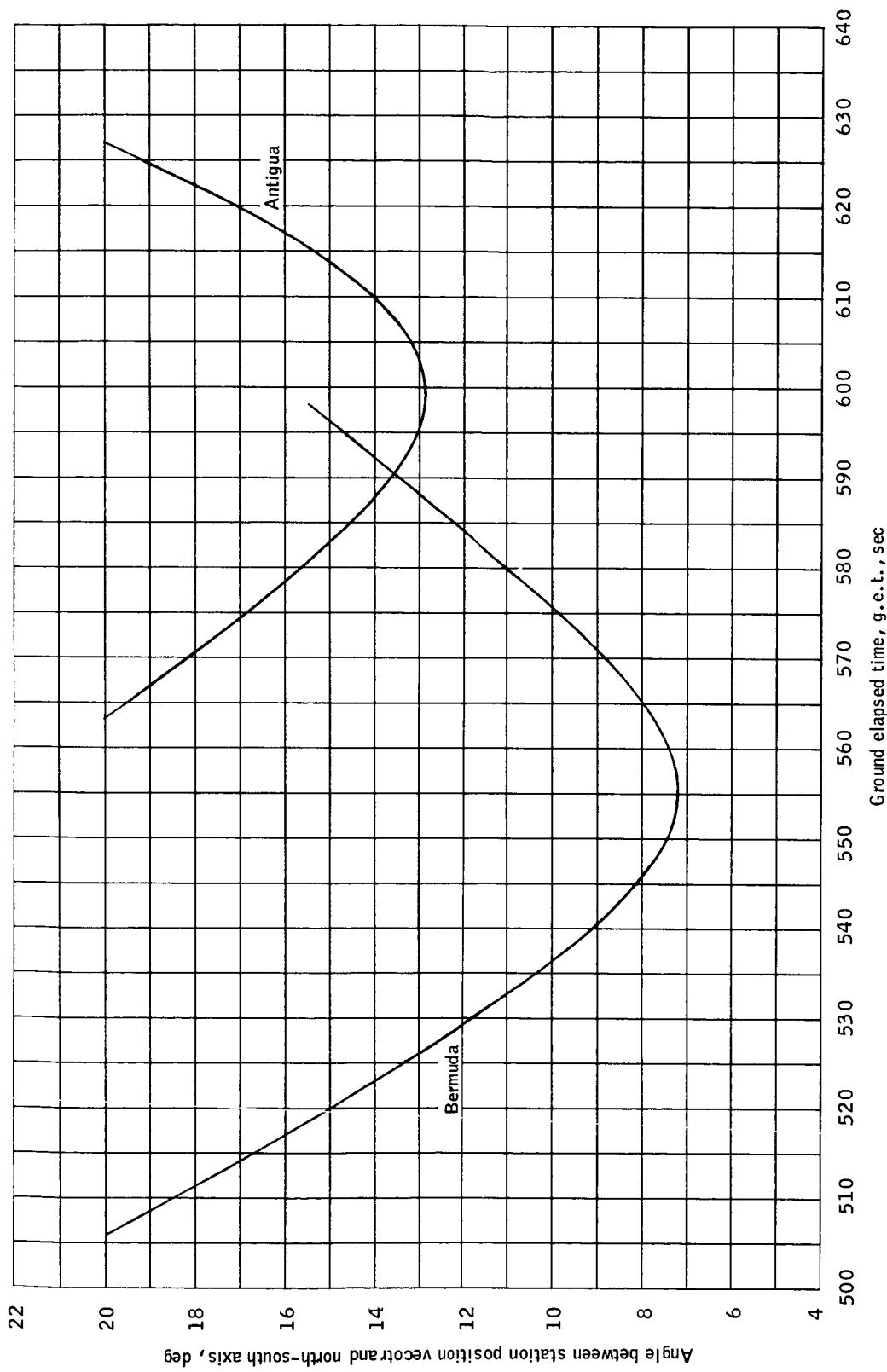
(n) 101-degree launch azimuth.

Figure 13 . - Continued.



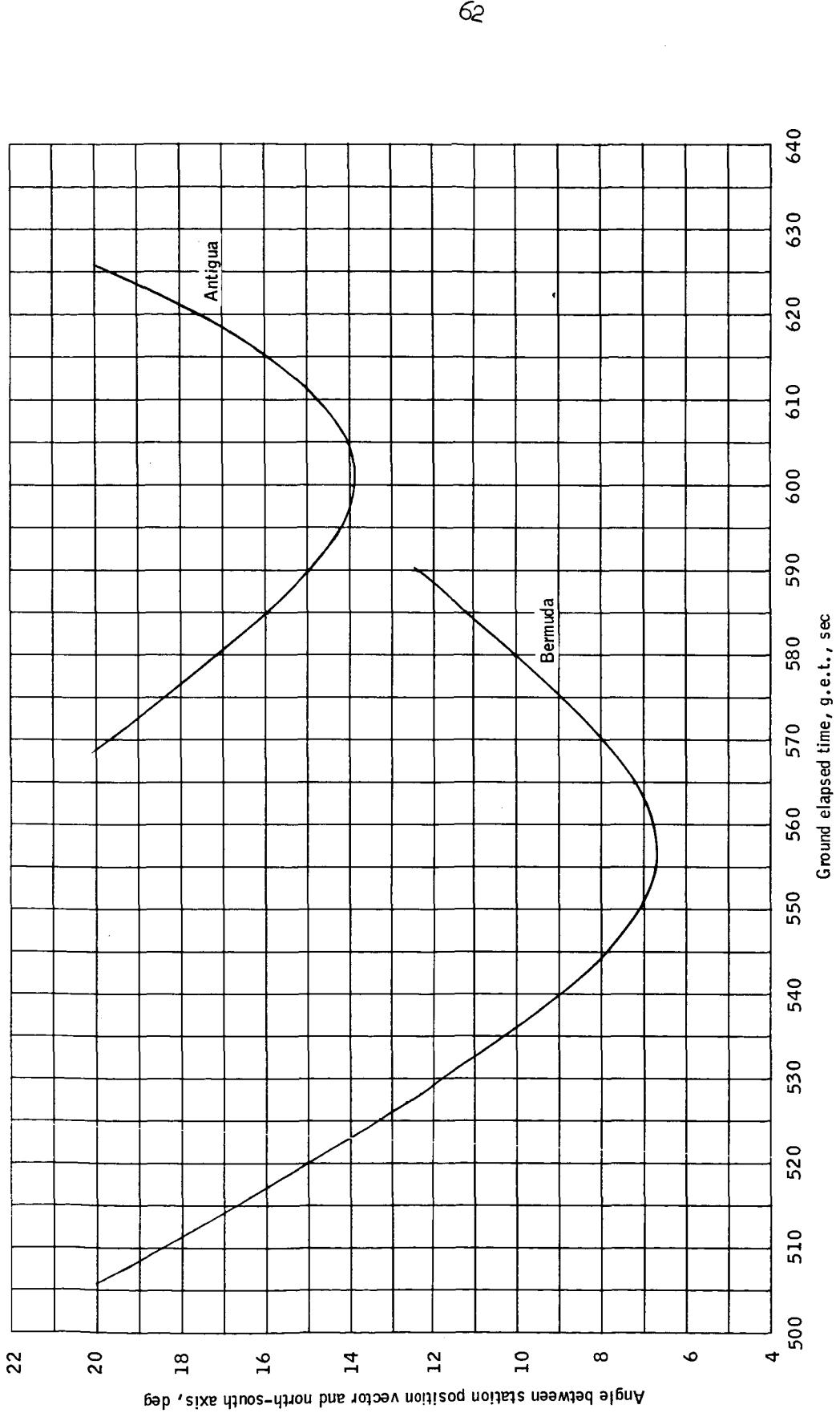
(a) 102-degree launch azimuth.

Figure 13.- Continued.



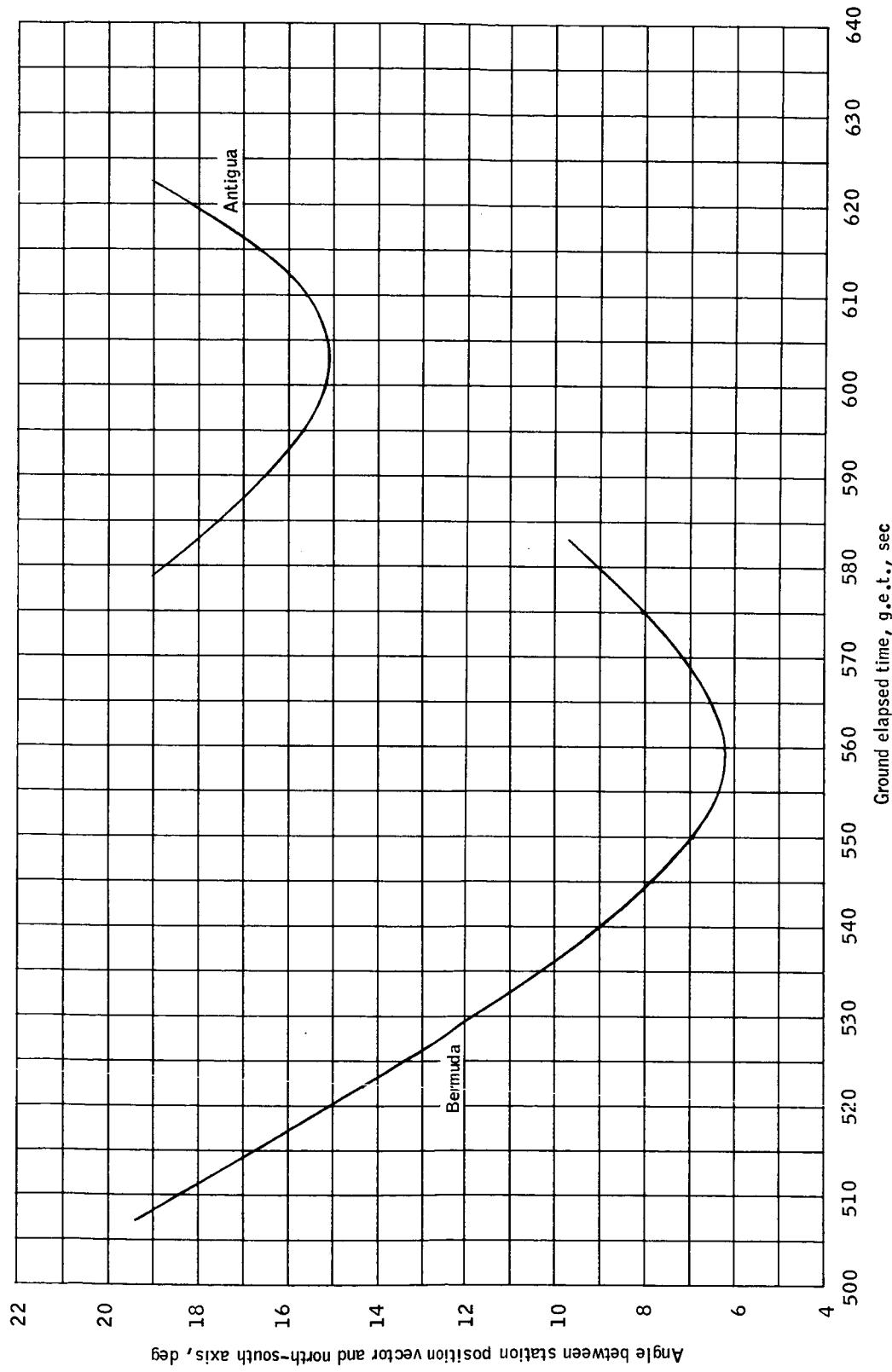
(p) 103-degree launch azimuth.

Figure 13.-Continued.



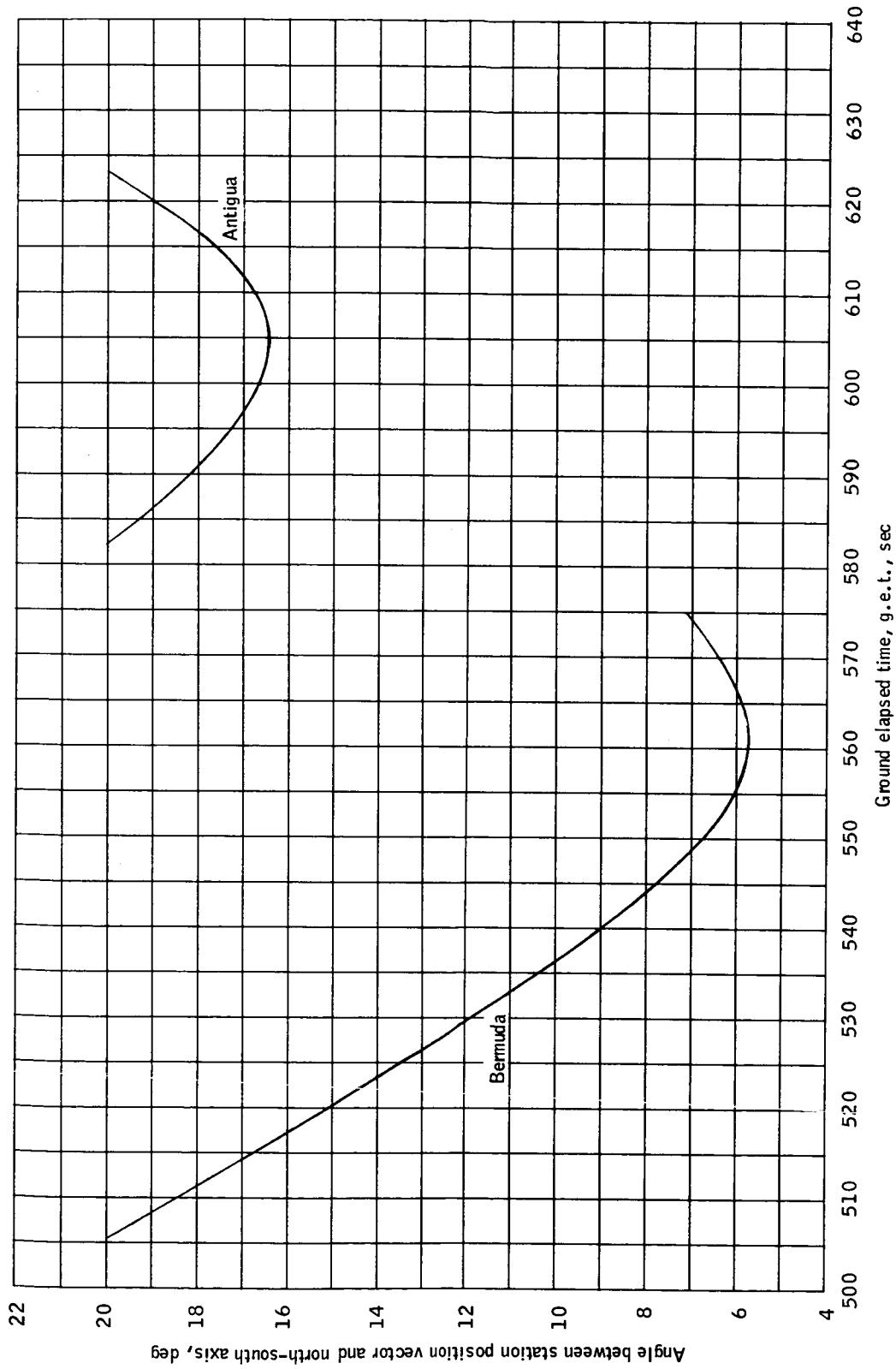
(q) 104-degree launch azimuth.

Figure 13 . - Continued.



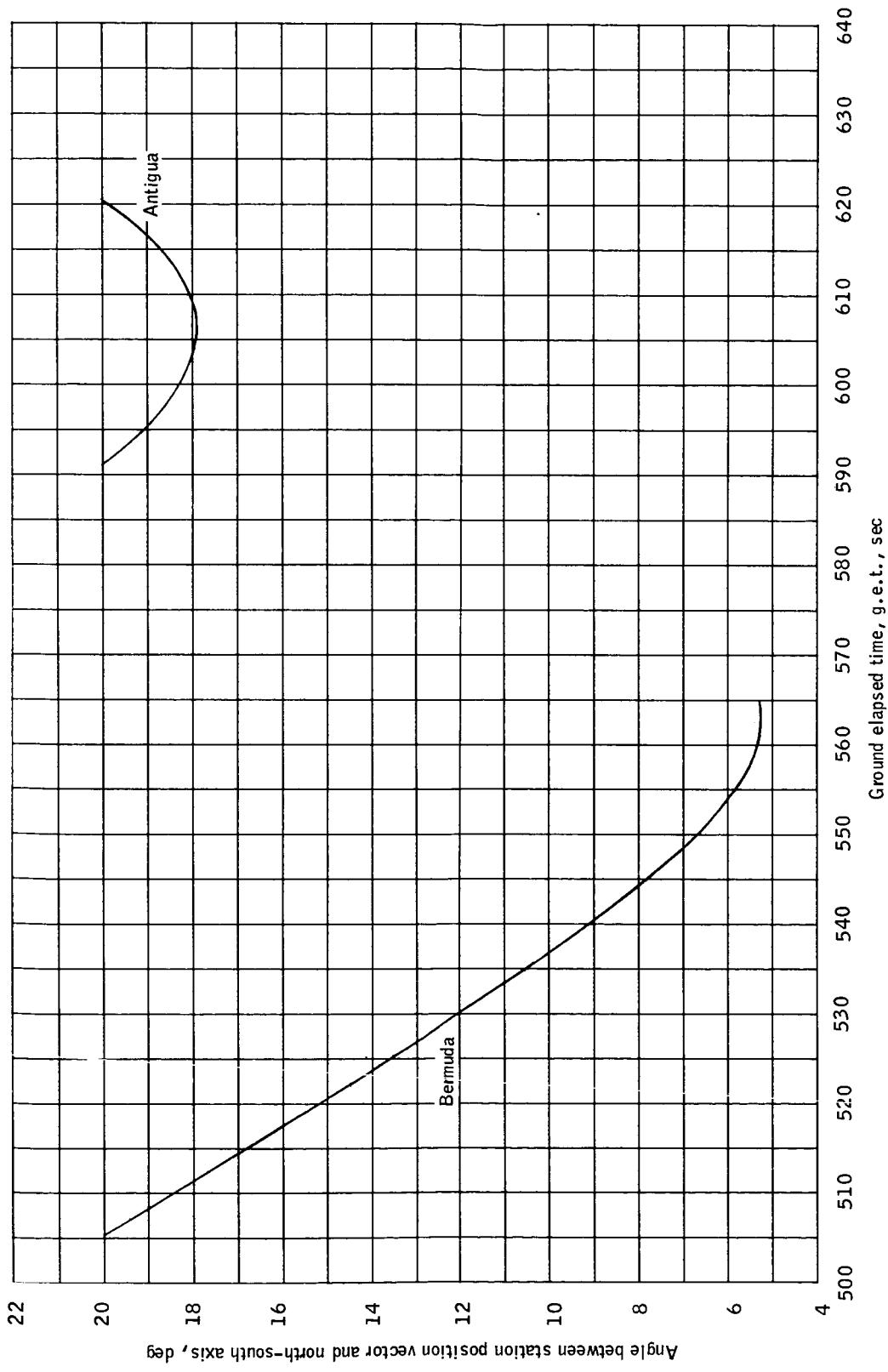
(b) 105-degree launch azimuth.

Figure 13.- Continued.



(s) 106-degree launch azimuth.

Figure 13.—Continued.



(t) 107-degree launch azimuth.

Figure 13.-Continued.

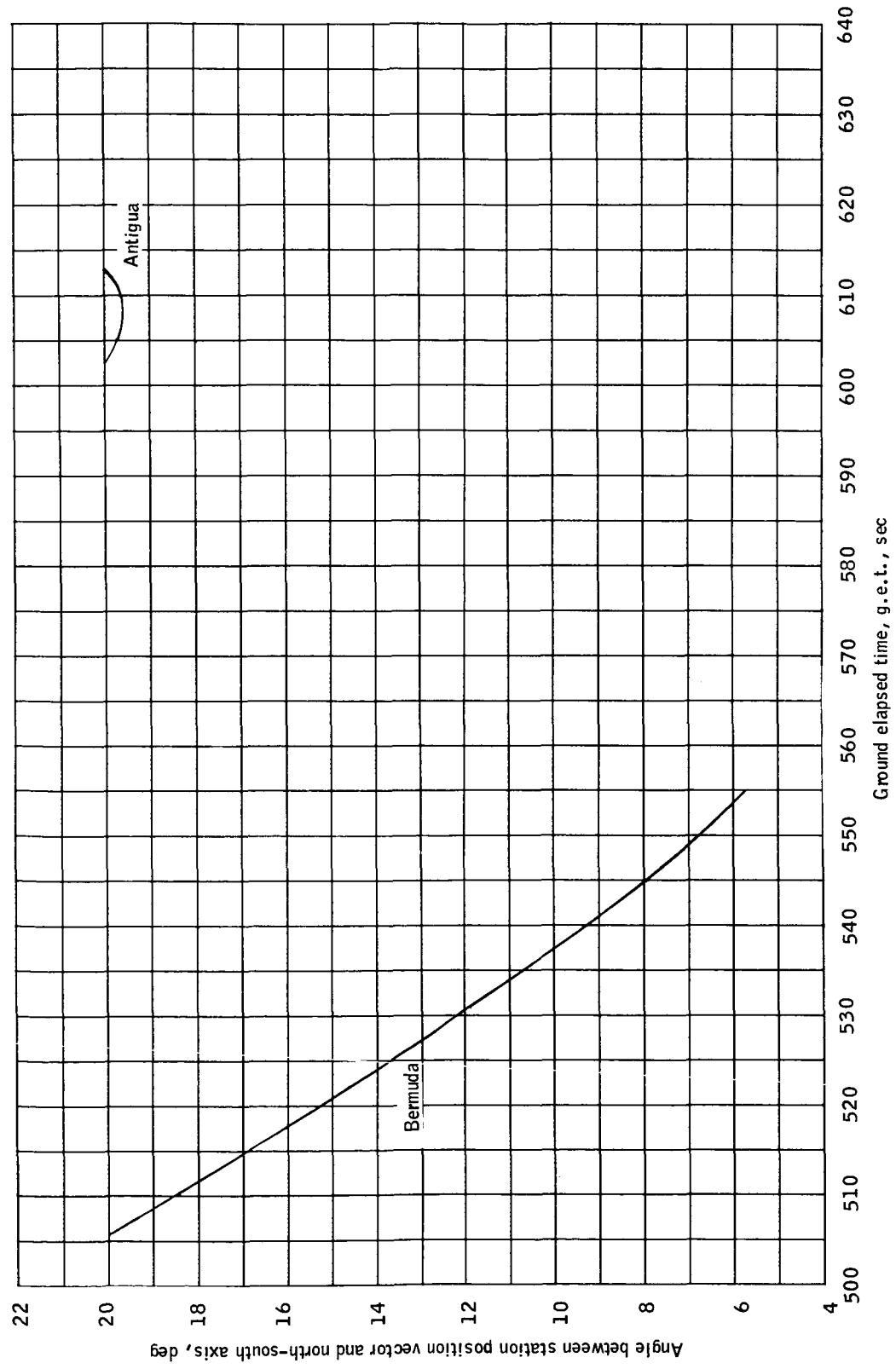


Figure 13.- Concluded.

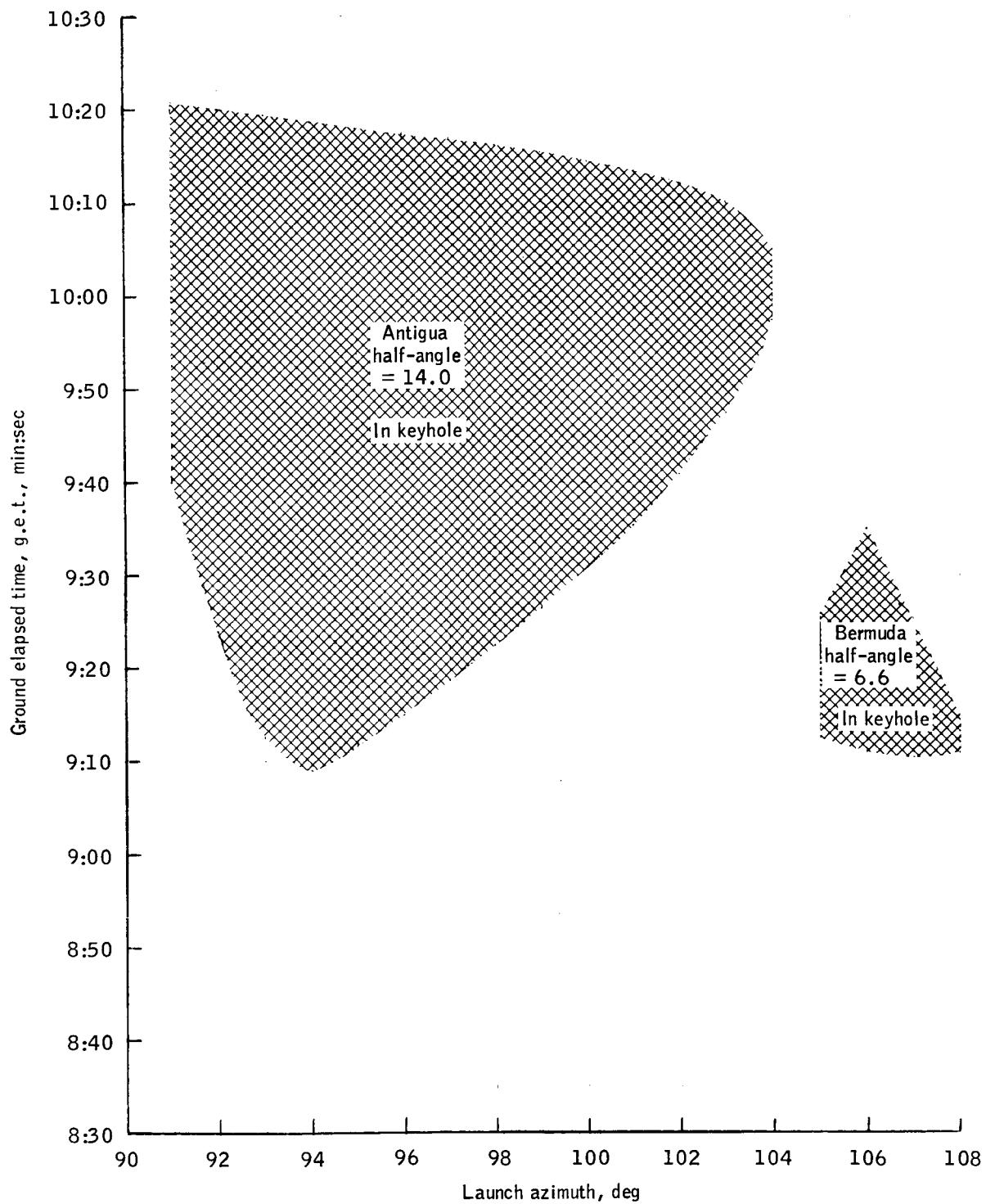


Figure 14.- Ground elapsed time in keyhole versus launch azimuth.

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